k-10
1/97

FINAL REPORT

PRELIMINARY (30%) DESIGN ALBION-SHERIDAN TOWNSHIP LANDFILL CALHOUN COUNTY, MI

Prepared for
Cooper Industries
Houston, Texas

and

Corning, Inc.
Corning, New York

January 1997

Woodward-Clyde

38777 West Six Mile Road
Suite 200
Livonia, Michigan 48152
6E13045

FINAL REPORT

PRELIMINARY (30%) DESIGN ALBION-SHERIDAN TOWNSHIP LANDFILL CALHOUN COUNTY, MI

Prepared for
Cooper Industries
Houston, Texas

and

Corning, Inc.
Corning, New York

January 1997

Woodward-Clyde

38777 West Six Mile Road
Suite 200
Livonia, Michigan 48152
6E13045

TABLE OF CONTENTS

Section 1 Introduction 1-1

1.1 Purpose Of Remedial Design Report 1-1
1.2 Site Description 1-1
1.2.1 Location 1-1
1.2.2 History 1-2
1.2.3 Landfill Characteristics 1-2
1.2.4 Contaminants Of Concern 1-2
1.2.5 Geology 1-2
1.2.6 Groundwater 1-3
1.3 Summary Of Previous Activities 1-3
1.3.1 Additional Monitoring Well Installation 1-4
1.3.2 Groundwater Sampling And Analyses 1-5
1.3.3 Site Surveying 1-7
1.3.4 Additional Horizontal And Vertical Waste Delineation 1-7
1.3.5 Native Species Revegetation Study 1-8
1.3.6 Air Emissions Study 1-8
1.4 Organization Of Report 1-9
1.5 Scope Of Work Checklist 1-9

Section 2 Description Of Remedial Action 2-1

2.1 Purpose 2-1
2.2 Description Of Remedial Action 2-1

Section 3 Design Criteria 3-1

3.1 Key Applicable Or Relevant And Appropriate Requirements 3-1
3.1.1 Action Specific 3-1
3.1.2 Chemical Specific 3-2
3.1.3 Location Specific 3-2
3.2 Existing Conditions 3-2
3.3 Evaluation Of Alternative Materials And Design Elements 3-2
3.3.1 Grading Materials 3-3
3.3.2 Cover System Materials 3-4
3.3.3 Passive Gas Venting System 3-4
3.3.4 Conclusions 3-5
3.4 Drum Removal 3-5
3.5 Waste Consolidation And Site Grading 3-5
3.6 Passive Gas Control System 3-6
3.7 Cover System Components 3-6
3.7.1 Stormwater And Erosion Controls 3-7
3.8 Floodplain 3-7
3.9 Wetlands 3-7
3.10 Endangered Species And Fauna 3-8

TABLE OF CONTENTS

Section 4 Design Elements And Analysis 4-1

4.1 Area Drum Removal And Disposal 4-1
4.2 Waste Movement And Site Grading 4-1
4.3 Passive Landfill Gas Control 4-2
4.4 Cover System 4-2
4.4.1 Foundation Layer 4-3
4.4.2 Flexible Membrane Liner (FML) 4-3
4.4.3 Cover Soil 4-3
4.4.4 Topsoil/Vegetative Layer 4-4
4.4.5 Stormwater And Erosion Controls 4-4
4.5 Design Analysis 4-4
4.5.1 Slope/FML Stability 4-4
4.5.2 FML Anchor Trench Depth/Runout Length 4-5
4.5.3 Soil Loss From Cover System 4-5
4.5.4 Stormwater Runoff 4-6
4.5.5 Hydrologic Evaluation Of Landfill Performance (HELP) 4-6
4.5.6 Passive Landfill Gas Horizontal Well Spacing 4-6
4.6 Location Of Construction Activities 4-7
4.6.1 Contractor Staging/Material Storage 4-7
4.6.2 Landfill Closure Activities 4-7
4.6.3 Material Borrow Sources 4-8

Section 5 Plans And Specifications 5-1

5.1 Design Drawings 5-1
5.2 Technical Specifications 5-1

Section 6 Real Estate, Easements And Permit Requirements 6-1

6.1 Introduction 6-1
6.2 Deed Restrictions 6-1
6.3 Easements 6-1
6.3.1 Environmental Monitoring 6-1
6.3.2 Construction 6-1
6.4 Permit Requirements 6-2

Section 7 Contracting Strategy And Construction Schedule 7-1

7.1 Contracting Strategy 7-1
7.2 Construction Schedule 7-1

Section 8 Draft Performance Monitoring Plan 8-1

8.1 Overview 8-1

TABLE OF CONTENTS

Section 9 Draft Construction QA Plan 9-1

Section 10 Draft Contingency Plan 10-1

10.1 Contingency And Emergency Response Plan 10-1

Section 11 Long-Term Monitoring And Operation Requirements 11-1

11.1 Cover System Operation And Maintenance 11-1
11.2 Groundwater Monitoring System Operation And Maintenance 11-1
11.2.1 O&M Objective 11-1
11.2.2 O&M Monitoring Well Locations 11-1
11.2.3 O&M Groundwater Sampling And Analysis Program 11-1
11.2.4 Operation & Maintenance 11-2
11.3 Passive Gas Venting System Operation And Maintenance 11-2

LIST OF FIGURES

Figure 1-1 Site Location Map
Figure 7-1 Construction Schedule

LIST OF TABLES

Table 3-1 Applicable Relevant And Appropriate Requirements (Arar's) Summary For Albion-Sheridan Cover Design

DRAWINGS

Drawing 1 Location Maps and Drawing Index
Drawing 2 Existing Site Conditions
Drawing 3 Grading and Waste Consolidation Plan
Drawing 4 Cover System Sections and Details
Drawing 5 Stormwater Control Plan
Drawing 6 Stormwater Control Sections and Details
Drawing 7 Passive Landfill Gas Control Plan
Drawing 8 Passive Landfill Gas Control Sections and Details
Drawing 9 Perimeter Fence Plan and Details
Drawing 10 Reserved
Drawing 11 Reserved

TABLE OF CONTENTS

LIST OF APPENDICES

Appendix A Design Analysis Calculations
Appendix B Draft Performance Monitoring Plan
Appendix C Draft Construction Quality Assurance Plan

Woodward-Clyde Consultants (WCC) has prepared this Remedial Design Report (RDR) on behalf of Corning, Inc. and Cooper Industries (the Group) according to the Remedial Design (RD) Work Plan dated June 1996 for the Albion-Sheridan Township Landfill (ASTL) in Calhoun County, Michigan. This RDR has been completed in compliance with the proposed final remedial action presented in the Record of Decision (ROD) and the subsequent Consent Decree Statement of Work (SOW) issued for the site.

This Remedial Design Report contains the preliminary design for the landfill closure of the ASTL.

1.1 PURPOSE OF REMEDIAL DESIGN REPORT

The purpose of this Remedial Design Report is to provide the preliminary design for the landfill closure. The preliminary design corresponds with 30% completion of the design. This document also describes the major components of the design approach to meet the design objectives.

1.2 SITE DESCRIPTION

The information contained in Section 1.2 was derived from the Remedial Investigation (RI) Report (WW Engineering Service, April, 1994), the ROD and SOW.

1.2.1 Location

The Albion-Sheridan Township Landfill Site is an inactive landfill located at 29975 East Erie Road approximately one mile east of Albion, Michigan on the eastern edge of Calhoun County (Figure 1). The site occupies approximately 18 acres. The site is surrounded by a combination of residential, agricultural, commercial and industrial properties. One residence is located immediately adjacent to the landfill to the south and five additional residences are located approximately 1,000 to 1,500 feet (ft) southwest of the landfill along East Erie Road. An active railroad track borders East Erie Road to the south of the landfill, and beyond the railroad tracks lies the North Branch of the Kalamazoo River. South of the river is agricultural land. The site does not fall within the flood plain of the river. There are wetlands south of the site adjacent to the river, separated from the site by the railroad tracks and Erie Road, which are not expected to be impacted by site activities.

The Amberton Village housing development is located adjacent to the site on the east side, with the closest residences approximately 500 ft from the landfill. Several residences and commercial businesses are located along Michigan Avenue approximately 500 ft north of the site. Immediately west of the site is undeveloped land formerly used for agriculture. The Orchard Knoll subdivision is located approximately 1,500 ft northwest of the landfill. Approximately 2,000 ft northwest of the site is a landfill associated with Brooks Foundry. Approximately one mile west is the city of Albion, with a population of 10,066 according to the 1990 census. This figure does not include approximately 1,700 students enrolled at Albion College located in the City of Albion.

1.2.2 History

The ASTL Site had been used as a sand and gravel borrow pit and also used for open, unpermitted dumping for an unspecified period of time prior to 1966. From 1966 to 1981, the landfill was privately owned and operated by Mr. Gordon Stevick. The landfill accepted municipal refuse and industrial wastes from households and industries in the City of Albion and nearby townships. In the early 1970s, the Michigan Department of Natural Resources (MDNR) approved the landfill to accept an estimated 6,000 cubic yards of metal plating sludges. Other materials, such as paint wastes and thinners, oil and grease, and dust, sand, and dirt containing fly ash and casting sand were also disposed of at the site. The landfill ceased operation in 1981.

1.2.3 Landfill Characteristics

The landfill is currently covered with a 1 to 4 feet thick layer of silty sand with some gravel. The cover thickness averages approximately two feet. Refuse is present within the cover material at some locations, and includes sludge, glass fragments and insulation. Refuse material is scattered at the ground surface throughout the landfill, particularly on the slopes; this material includes metal, plastic, concrete, asphalt, 55 gallon drums, wood, tires, a storage tank, and a junk crane.

The landfill ranges from 16 to 35 ft thick. During drilling of leachate head wells, refuse interlayered with medium to fine sand was encountered. Landfill gases including total VOCs at concentrations greater than 10,000 ppm were encountered during the installation of wells and subsidence monuments on the landfill. Subsurface soil/waste samples contained up to 1,500 ppm total VOCs.

1.2.4 Contaminants of Concern

Waste samples from borings contained numerous constituents, including 10 VOCs, 19 semi-volatile organic compounds (SVOCs), and 11 pesticides/PCBs. Several inorganic substances were present above background levels in subsurface soils, including antimony, arsenic, chromium, copper, lead, mercury and zinc. The highest concentrations in soil include lead at 208 mg/kg, arsenic at 13.1 mg/kg and chromium at 13.5 mg/kg. Toxicity Characteristic Leachate Procedure (TCLP) metals analysis results indicated the presence of barium and lead in the leachate, both below hazardous waste levels.

Landfill constituents in groundwater extend southwest of the landfill for approximately 900 ft and extends vertically to a depth of approximately 45 ft below the water table. The unconsolidated aquifer plume contains 1,2-dibromo-3-chloropropane and antimony at concentrations above their respective federal Maximum Contaminant Level (MCL). The bedrock aquifer plume contains vinyl chloride at the MCL and arsenic above the MCL, at concentrations up to 126 ug/l.

1.2.5 Geology

The geology of the site is characterized by approximately 20 to 54 ft thick glacial sediments overlying sedimentary bedrock. The glacial sediments consist of outwash sands and till, while the bedrock consists of fractured sandstone of the Marshall Formation.

Generally, the uppermost portion is composed of outwash sand from the ground surface to a depth of 10 to 30 ft below ground surface. Beneath the outwash sand is a glacial till composed primarily of silty sand with discontinuous layers containing silt and/or clay. There are no obvious clay confining layers beneath the site that are extensive enough to hydraulically isolate the landfill materials from bedrock groundwater.

The uppermost bedrock beneath the site is comprised of Mississippian-aged sandstone of the Marshall Formation. The top of the bedrock beneath the site is generally encountered at an elevation of approximately 935 to 925 feet mean sea level (MSL). The uppermost portion of the sandstone (generally the upper 5 to 25 feet) is intensively weathered and very weak. Beneath the weathered portion, the rock is more competent and better cemented; however, it is still highly fractured. The sandstone is characterized by very fine to fine-grained quartz containing trace amounts of pyrite, mica and coal.

1.2.6 Groundwater

Groundwater beneath the site is encountered within the unconsolidated and bedrock aquifers. The two units are hydraulically connected in the vicinity of the site as evidenced by water level elevations in nested monitoring wells. In addition, no significant clay layers or aquicludes were encountered during well installation drilling.

Groundwater was encountered in the unconsolidated unit throughout the site at depths of 10 to 30 ft below ground surface. Groundwater was at or very near the ground surface at the well locations adjacent to the North Branch of the Kalamazoo River. The occurrence of shallow groundwater at the site is controlled primarily by infiltration of precipitation and the characteristics of the unconsolidated unit.

The direction of groundwater flow in the unconsolidated unit is west-southwest in the vicinity of the landfill and curves in a more southerly direction near the North Branch of the Kalamazoo River. The average hydraulic conductivity of this unit was determined during the Remedial Investigation (RI) to be 29 ft/day. The groundwater flow velocity in the unconsolidated unit was calculated to be approximately 0.29 ft/day or 106 ft/yr.

Comparing the water level data from both bedrock wells and unconsolidated wells indicates there is a vertical component to groundwater flow. The vertical component of groundwater flow is generally downward in the northern part of the site and upward south of the site near the river. The downward gradient suggests that the northern portion of the site is an area of groundwater recharge, and the upward gradient south of the site is consistent with groundwater discharging to the North Branch of the Kalamazoo River. In addition, there is an upward gradient in the MW04 well between the deep bedrock and the shallow bedrock. This indicates that the groundwater in the deep bedrock is discharging to the shallow and weathered bedrock aquifers, thus helping to protect the deeper groundwater from contamination.

1.3 SUMMARY OF PREVIOUS ACTIVITIES

In 1986, a U.S. EPA Field Investigation Team (FIT) contractor, performed a site screening inspection to score the site for the Hazard Ranking System (HRS). In 1988, U.S. EPA proposed that the site be included on the National Priority List (NPL), and in 1989, the site was officially placed on the NPL and designated a Superfund site.

During 1988 and 1989, a U.S. EPA technical team observed surface debris on the landfill, including drums which appeared to contain grease and paint waste. Some of the waste was later classified RCRA hazardous waste for toxicity and ignitability. Some waste samples contained VOCs, including ethylbenzene, toluene, tetrachloroethylene, 1,1,1-trichloroethane, and xylene.

On March 19, 1990, the U.S. EPA issued a Unilateral Administrative Order (UAO) to five potentially responsible parties (PRPs) stating that removal action was appropriate, and on May 3, 1990, the UAO was amended to delete one of the parties.

Later in 1990, two PRPs performed the removal of approximately 46 drums from the surface of the landfill. Twenty two drums were overpacked and sent to an off-site facility for incineration. The remaining 24 drums were crushed and sent to a Type 2 landfill.

In 1991, the site was selected for the presumptive remedy for CERCLA municipal landfill sites, one of the clean-up accelerating Superfund tools.

U.S. EPA initiated the RI/FS in January 1992, and the completed work reports (Final Remedial Investigation Report of the Albion-Sheridan Township Landfill, Albion, Michigan April, 1994 and the Final Presumptive Remedy Feasibility Study Report of the Albion-Sheridan Township Landfill, Albion, Michigan September, 1994) performed by WW Engineering & Science (WWES) were placed in the Administrative Record in late 1994.

U.S. EPA decided on a remedial action to be implemented at the site and executed a ROD on March 1995, on which the state has given its concurrence.

On June 6, 1995, the U.S. EPA issued special notice letters to respondents to initiate negotiations on a consent decree for performance of the Remedial Design/Remedial Action (RD/RA) for the site. Respondents declined to enter into a consent decree to conduct the RD/RA for the site in accordance with the ROD and the Statement of Work (SOW) for the site so the Agency issued an Unilateral Administrative Order (UAO) on October 11, 1995.

WCC completed pre-design studies field work during August, 1996 and completed the Pre-Design Studies Report, Albion-Sheridan Township Landfill Calhoun County, Michigan, dated December, 1996 (PDR) which was approved by U.S. EPA on December 4, 1996. The pre-design studies consisted of installing additional groundwater monitoring wells, groundwater sampling and analyses, site surveying, further delineating the horizontal and vertical extent of waste, performing a native species revegetation study and conducting an air emissions study. The following sections briefly summarize the results of the pre-design studies.

1.3.1 Additional Monitoring Well Installation

Four ground water monitoring wells were scheduled to be installed during the pre-design studies. However, due to the inability to reach a monitoring well access agreement with the landowner (Walt Gill and Sons), two monitoring wells (MW15SB and MW 09DB) were unable to be installed.

Two monitoring wells (MW16SB and MW16DB) were installed during the week of August 5-12, 1996, by Environmental Drilling and Contracting, Inc. of Holland, Michigan. All drilling and well installation was supervised and documented by WCC personnel.

1.3.2 Groundwater Sampling and Analyses

Groundwater samples were collected on August 13-15, 1996 from all existing and new monitoring wells located at the site and adjacent properties as indicated in Figure 2. Verbal permission was received from Mr. Dick Gill prior to accessing his property.

Samples collected for laboratory analysis from each monitoring well were analyzed for:

- Target Compound List - Volatile Organic Compounds (TCL-VOCs)
- TCL-Semi-Volatile Organic Compounds (SVOCs)
- TCL-Pesticides/Polychlorinated biphenyls (PCBs)
- Target Analyte List (TAL)-Metals (Dissolved)
- Cyanide (Total)
- 1,2-dibromo-3-chloropropane

Field measurements of pH, specific conductance, dissolved oxygen (DO), Eh, temperature, depth of water, and groundwater elevation for all of the wells were obtained during the pre-design study and are summarized in the PDR.

Organic Analyte Analyses

MW03SG sample results revealed vinyl chloride present at the quantitation limit of 1.0 μg/L and MW07SG sample results revealed chloroethane present at the quantitation limit of 1.0 μg/L.

Bis (2-Ethylhexyl) phthalate was the only semi-volatile organic compound (SVOC) detected. It was detected in MW05SG at 6.4 μg/L which is above the 6.0 μg/L MCL. MW05SG is an upgradient monitoring well, according to documented groundwater elevations.

Following data validation, there were no other detections of VOC or SVOC compounds in the consolidated (bedrock) monitoring wells.

Inorganic Analyte Analyses

Inorganic analyte results from wells screened in the unconsolidated sediments are summarized as follows:

- Cadmium, cyanide and zinc were not detected.
- Arsenic was detected in 3 groundwater samples, all below the 50 μg/L MCL. Arsenic concentrations ranged from 7.9 μg/L in MW04SG to 13.2 μg/L in MW07SG.
- Calcium results ranged from 46,400 μg/L in MW08SG to 145,000 μg/L in MW03SG.
- Antimony was detected in MW01SG at 5.7 μg/L and in MW12SG at 5.6 μg/L.

- Iron was detected in 7 monitoring well samples ranging from 140 μg/L in MW12SG to 4,320 μg/L in MW03SG.
- Potassium was only detected in MW03SG and MW07SG at 22,600 μg/L (23,400 μg/L in duplicate sample) and 25,300 μg/L, respectively.
- Magnesium was detected in all monitoring well samples ranging from 11,800 μg/L in MW12SG to 53,200 μg/L in MW03SG.
- Manganese was detected in all monitoring well samples, except for MW01SG and MW08SG, in concentrations ranging from 38.1 μg/L in MW09SG to 465 μg/L in MW13SG.
- Sodium was detected in all monitoring well samples, except MW01SG, MW04SG, MW06SG and MW08SG, in concentrations ranging from 5,310 μg/L in MW09SG to 141,000 μg/L in MW03SG.
- Iron levels exceeded the 300 μg/L aesthetic drinking water value at MW03SG and MW07SG with levels of 4,320 μg/L and 4,050 μg/L, respectively.
- Manganese levels exceeded the 180 μg/L residential cleanup criteria in upgradient wells MW02SG (194 μg/L) and MW05SG (183 μg/L) and in downgradient wells MW03SG (352 μg/L), MW07SG (1,270 μg/L) and MW13SG (465 μg/L).

Inorganic analyte results from wells screened in the bedrock are summarized as follows:

- Arsenic exceeded the 50 μg/L MCL in MW06SB at a concentration of 130 μg/L. Arsenic was also detected in MW04SB (10 μg/L), MW04WB (15.8 μg/L), MW06WB (32.9 μg/L) and MW16SB (7.9 μg/L).
- Cadmium was not detected in any of the bedrock monitoring wells.
- Antimony was only detected in MW09SB at 5.2 μg/L and zinc was only detected in MW04DB at 29.6 μg/L and MW07WB at 43 μg/L.
- Calcium was detected in all bedrock monitoring well samples at concentrations ranging from 54,800 μg/L in MW08WB to 148,000 μg/L in MW03WB.
- Iron was detected in all bedrock monitoring well samples except MW04SB, MW07SB and MW09WB. Iron concentrations ranged from 186 μg/L in MW08WB to 5,330 μg/L in MW03WB.
- Potassium was detected in all bedrock monitoring well samples except MW04DB, MW07SB, MW07WB, MW08SB, MW08WB and MW16DB at concentrations ranging from 6,420 μg/L in MW05SB to 45,400 μg/L in MW04SB.
- Magnesium was detected in all bedrock monitoring well samples except, for MW07SB, at concentrations ranging from 14,500 μg/L in MW08WB to 51,700 μg/L in MW03WB.
- Maganese was detected in all bedrock monitoring well samples, except for MW07SB, at concentrations ranging from 25.4 μg/L in MW08WB to 297.0 μg/L in MW03WB.

- Sodium was detected in all bedrock monitoring well samples, except for MW08WB, at concentrations ranging from 8,310 μg/L in MW04DB to 151,000 μg/L in MW03WB.
- Iron levels exceeded the 300 μg/L aesthetic drinking water value at all bedrock monitoring wells except MW02SB, MW02WB, MW04SG, MW04SB, MW07SB, MW08WB and MW09WB.
- Manganese exceeded the 180 μg/L residential cleanup criteria in upgradient wells MW01WB (333 μg/L) and in downgradient wells MW03WB (297 μg/L), MW04SG (16,900 μg/L - 18,100 μg/L in FD-2) and MW16SB (202 μg/L).

1.3.3 Site Surveying

The accuracy of the existing topographic map (WW Engineering & Science, April, 1994) and boundary information completed during the RI was verified using standard surveying practices and existing benchmarks by a licensed surveyor, Atwell-Hicks, Inc., Ann Arbor, Michigan. The location and elevation of the two new monitoring wells and test pits were also surveyed by Atwell-Hicks, Inc.

The existing topographic information provided from the WW Engineering & Science aerial survey of the Albion-Sheridan site from 1994 was determined to have some inconsistencies when compared to the random topographic checks provided by the 1996 Atwell-Hicks pre-design survey. The random survey points generated from the ground survey indicate the topographic information from the 1994 aerial survey on the south end of the landfill property is approximately two (2) to five (5) feet above the existing ground surface. Subsidence data provided in the WW Engineering & Science investigation reports and confirmed in the 1996 survey can not substantiate any large changes in elevation over this section of the landfill site. By eliminating subsidence, the conclusion reached is that the original aerial topographic survey was inaccurate. This could be attributed to a variety of factors, but most likely due to the effect trees and vegetation have on the photogrammetric analysis of the aerial photos.

1.3.4 Additional Horizontal and Vertical Waste Delineation

Work for the waste fill area characterization was completed in compliance with Technical Memorandum No. 1 dated June 31, 1996. The purpose of this task was to gather further information on the vertical and horizontal extent of waste in order to analyze the design for potential footprint consolidation of the cover system. The schedule for these activities was coordinated in conjunction with the groundwater well installation/sampling and occurred on August 9-13, 1996. All work was completed in Level D personal protective equipment as the air monitoring results at test pit locations during excavation did not violate action levels. Twenty-six test pits to determine the horizontal extent of waste and eight test pits to determine the vertical extent of waste were completed.

The horizontal edge of waste was found to generally conform to the edge of waste shown in the RI. Areas where the boundary differed were on the south and east edges of the landfill. The previous horizontal waste boundary that was outlined in the RI indicated approximately 17 acres of the site contained waste. Based on the edge of waste locations verified by this study, the waste area can be more accurately estimated at 16 acres.

Wastes encountered during the test pit excavations tended to be industrial and household waste on the major portion of the landfill. The areas north and northeast of leachate monitoring well LF-1 contained waste that consisted of large pieces of metal slag, foundry sand and based on odor, appear to be petroleum contaminated soils.

The composition of waste observed during the vertical extent of waste investigation supported the observations made in the horizontal extent investigation as to the waste composition in the various sections of the landfill. The bottom extent of waste was located at four (4) of the eight (8) test pits that were excavated. The other test pits encountered waste deeper than the digging capabilities of the backhoe (greater than 18 feet) and further excavation was not done in these areas. No drums were found during either the vertical or the horizontal extent of waste investigation.

1.3.5 Native Species Revegetation Study

The purpose of this study was to evaluate the costs and practicability of revegetating the ASTL cap with native species. The study concluded that revegetating the landfill cap at ASTL with native species has substantial merit.

1.3.6 Air Emissions Study

The SOW for the remedial action at the ASTL establishes the requirements for performance of the remedial action. One of these requirements is the following:

At all times during the performance of the remedial action, air emissions shall not exceed a total cancer risk of 1×10^{-6} at the fenceline, using risk calculation methods set forth in Risk Assessment Guidance for Superfund. In addition, the air emissions shall not exceed any Applicable or Relevant and Appropriate Requirements (ARARs).

WCC used two different computer models (Landfill Air Emissions Estimation Model (USEPA, 1991, Landfill Air Emissions Estimation Model, EPA-600/8-90-085a, April 1991 and Air/Superfund National Technical Guidance Study Series, Models for Estimating Air Emission Rates from Superfund Remedial Actions, USEPA 1993).) to predict chemical-specific landfill gas generation rates and downwind concentrations of these chemicals to demonstrate that the total cancer risk level of 1×10^{-6} will not be exceeded at the fenceline from landfill remediation and waste consolidation activities.

The long-term concentrations for all nine carcinogenic compounds were compared to the MDEQ screening levels (IRSLs). The models determined that none of the chemical concentrations exceeded the screening levels and the risk level of 1×10^{-6} (9.30×10^{-7} actual) would not be exceeded for any individual compound.

The final step was to ensure that the sum of the individual risks does not exceed 1×10^{-6}. The unit risks were multiplied by the long-term concentrations to determine individual cancer risks. The individual risks were then added together to determine the total cancer risk at the fenceline.

The total cancer risk did not exceed 1 x 10^{-6}. Therefore, the SOW requirement is expected to be complied with at all times.

Based on the results, the SOW requirements will be met by a passive gas venting system without any controls on gas emissions. It should be noted that the Landfill Air Emissions Model predicted a decreasing trend in the gas production rate starting approximately 2 years after landfill closure (1981).

1.4 ORGANIZATION OF REPORT

The PDR is divided into eleven principle sections:

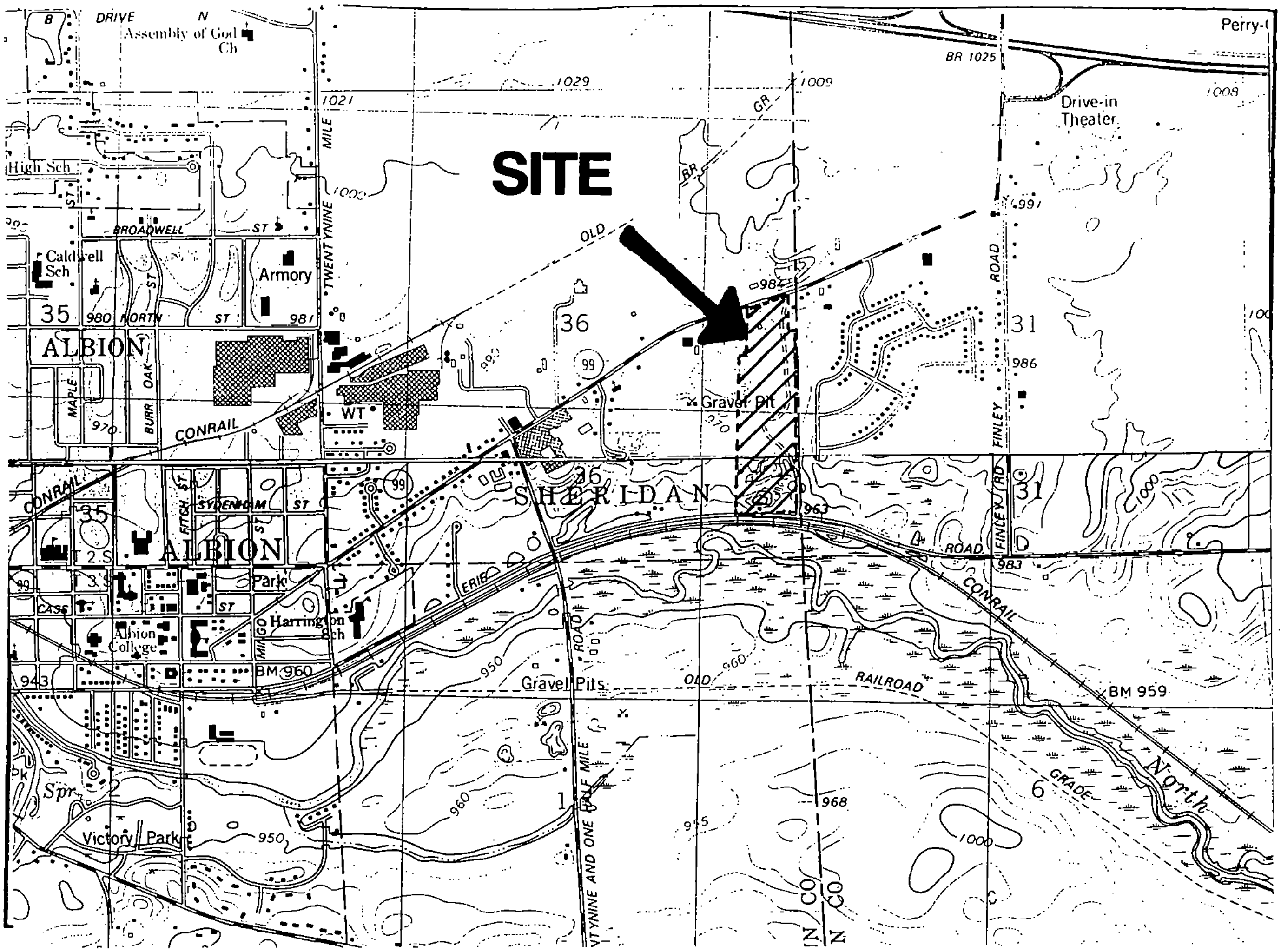
- Section 1 provides an introduction, provides a site description, and summarizes previous work at ASTL.
- Section 2 provides a description of the remedial action.
- Section 3 defines the design criteria.
- Section 4 presents the design elements and analysis.
- Section 5 describes the plans and specifications.
- Section 6 presents the real estate easements and permit requirements.
- Section 7 discusses the construction schedule and contracting strategy.
- Section 8 presents an overview of the performance monitoring plan.
- Section 9 presents an overview of the construction quality assurance plan.
- Section 10 presents an overview of the contingency plan.
- Section 11 presents the expected long-term monitoring and operation requirements.
- Appendix A provides supporting documentation.
- Appendix B presents the Draft Performance Monitoring Plan and Appendix C presents Draft Construction Quality Assurance Plan.

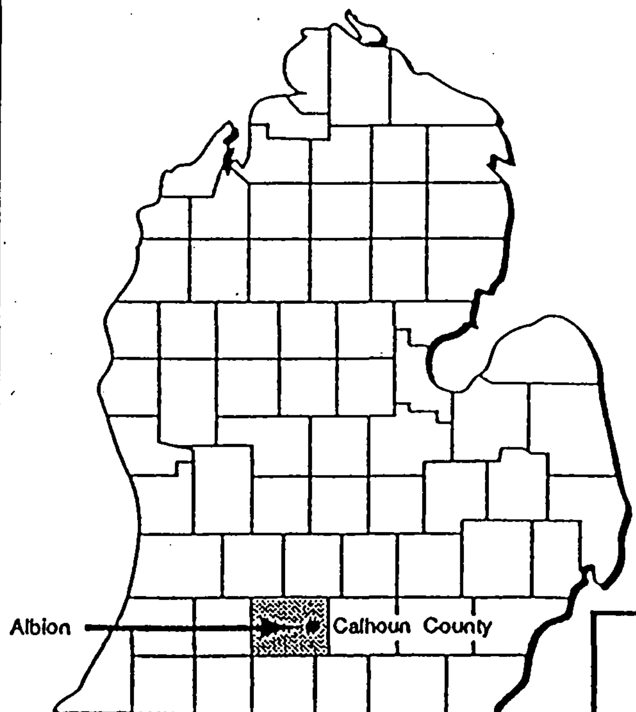
1.5 SCOPE OF WORK CHECKLIST

The SOW details eleven items (Page 13) to be submitted as part of the preliminary design. For information and review purposes the eleven items and their location in the PDR are listed below.

Report Location	Report Location
Preliminary plans, drawings, and sketches, including design calculations	Sections 3-5, Figures and Appendices of the PDR
Design assumptions and parameters, including design restrictions, process performance criteria, appropriate unit processes for the treatment train, and	Sections 3-5 of the PDR

expected removal or treatment efficiencies for both the process and waste (concentration and volume)	
Proposed cleanup verification methods, including compliance with Applicable or Relevant and Appropriate Requirements (ARARs)	Appendix B and Section 3
Outline of required specifications.	Section 5 of the PDR
Proposed siting/locations of processes/construction activity	Section 7 of the PDR
Expected long-term monitoring and operation requirements	Section 11 of the PDR
Real estate, easement, and permit requirements	Section 6 of the PDR
Preliminary construction schedule, including contracting strategy	Section 7 of the PDR
Draft Performance Monitoring Plan	Section 8 of the PDR and Appendix B
Draft Construction Quality Assurance Plan	Section 9 of the PDR and Appendix C
Draft Contingency Plan.	Section 10. The contingency plan is expected to be included in the site health and safety plan





0 2,000 4,000

SCALE IN FEET

ALBION–SHERIDAN TOWNSHIP LANDFILL
ALBION, MICHIGAN

Woodward-Clyde Consultants
ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

SITE LOCATION MAP

DRN BY: SWH	DATE: MAR. 1996	PROJECT NO.	FIG. NO.
CHK'D BY: DS	DATE: MAR. 1996	6E13045	1-1

2.1 PURPOSE

The purpose of remedial action at the ASTL Site is to eliminate or reduce migration of contaminants to groundwater, and to protect human health and the environment from direct contact with contaminants in the landfill. The ROD describes the remedy as restrictive covenants/deed restrictions, drum removal, and the installation of a flexible membrane lined cap and gas collection system. The ROD also describes a contingent groundwater remedy if appropriate groundwater standards are not achieved.. The remedial action was selected in accordance with two threshold criteria, overall protection of human health and the environment, and compliance with the requirements of Federal and State Applicable or Relevant and Appropriate Requirements (ARARs).

The ROD requires design and implementation of the remedial action to meet the performance standards and specifications set forth in the ROD and the SOW. The performance standards include clean-up standards, standards of control, quality criteria and other substantive requirements, criteria or limitations including all ARARs set forth in the ROD, SOW and/or UAO.

2.2 DESCRIPTION OF REMEDIAL ACTION

The remedial action is described below:

Site Security

A permanent fence shall be installed and maintained at the site to prevent access and vandalism to the site. The site security system of the landfill shall:

- Consist of a minimum 6 ft high fence, with a minimum three-strand barbed wire permanent chain link fence and gates around the perimeter of the landfill.
- Encompass at a minimum the landfill waste.
- Post warning signs at 200 ft intervals along the fence and at all gates.
- The permanent fence shall be completed within 30 days of the landfill cap completion. The warning signs shall:
    - Advise that area is hazardous due to chemicals in the soil which pose a risk to public health through direct contact with soils.
    - Provide a telephone number to be used for further information.

Restrictive Covenants/Deed Restriction

Future development including, but not limited to, on-site excavation, construction and drilling shall be prohibited. The prohibition is achieved by filing with the Calhoun County recorder the restrictive covenants included in Appendix E of the UAO.

Institutional controls in the form of deed restrictions or a local ordinance shall be implemented 30 days after the approval of the pre-design studies report. The deed restrictions will prohibit the installation of any groundwater well which draws drinking water from the area noted in Figure 4 of the ROD to contain 2 ug/l of arsenic or more.

All restrictions regarding future development of the landfill shall be considered permanent. U.S. EPA may advise lifting the restrictions on future groundwater drinking water well installation when the arsenic concentrations in the groundwater area described in Figure 4 of the ROD remain below the MCL for two years.

Drummed Waste

Test pit area TP09 shall be excavated to uncover all drums. Solid or liquid waste drums from TP09, nine drums previously excavated by the MDNR temporarily stored on site, and drums encountered during consolidation or site preparation determined by the U.S. EPA to be structurally sound, shall be removed to the staging area for waste characterization.

Where practical, liquid wastes from structurally unsound drums encountered at TP09 area, or during consolidation or site preparation, shall be removed and transported to the staging area for subsequent characterization.

Excavated drums showing signs of degradation shall be overpacked. The overpacked drums shall be included with the on-site overpacked drums, temporarily secured on the surface of the landfill during test pitting. Overpacked drums shall be submitted for Resource Conservation and Recovery Act (RCRA) characterization and to determine disposal options.

The ROD requires that all excavated drums containing liquid and solid wastes containing constituents in concentrations exceeding land disposal restrictions or constituents for which incineration or stabilization treatment method is prescribed to be treated or disposed off-site.

Drums containing solid wastes not banned by land disposal restrictions, may be incorporated under the ASTL cap.

Landfill Cap

The landfill cap will cover the entire landfilled waste mass as delineated in the PDR. The landfill cap will meet or exceed the substantive requirements of RCRA subtitile D (40 CFR Part 241) and any more stringent requirements of Michigan NREPA 451, 1994 Part 115 which are applicable or relevant and appropriate to the site as determined by the U.S. EPA. The multi-layer landfill cover design at a minimum will include (from the surface downward):

- Vegetative Cover: Native plant species will be used if practical, to establish a vegetative cover to control erosion.
- Topsoil Layer: The topsoil layer, which is a minimum of 6 inches (in) thick, will be placed to sustain plant growth, control erosion and promote drainage.
- Cover Soil Layer: The cover soil layer will be 18-in thick. A filter fabric may be placed between the cover soil and the drainage layer to minimize fill material from clogging the drainage layer.

- Drainage Layer: The drainage layer will consist of 6-in of sand no coarser than 3/8-in, with a minimum hydraulic conductivity of 1×10^{-2} cm/sec, or technically equivalent synthetic material with a transmissivity of at least 3×10^{-5} m^2/sec.
- Flexible Membrane Liner (FML): The FML will be equivalent to or less permeable than a 40 mil low density polyethylene (LDPE), or 30 mil polyvinyl chloride (PVC).
- Gas Collection Layer: The gas collection layer will consist of a 12-in. thick sand layer on top of the existing waste mass.

The following components were identified in the SOW as parts of the construction and installation activity of the landfill cap:

- Consolidating the waste on the east edge of the landfill towards the west so that the east boundary of the landfill cap and any perimeter road needed for maintenance is contained on lot 28.
- Consolidating the waste on the south edge of the landfill so that the south boundary of the landfill cap and any perimeter road needed for maintenance is contained in lot 28, parcel 3, and parcel 2 north of a line extending to the east from the north boundary of parcel 1. If lot 28 parcels 1 and 2 are acquired, waste consolidation of the south edge will not be necessary.
- Grading the landfill to attain grades and slopes required to facilitate drainage and to meet ARARs. Regrading may be used to achieve sub-cap contours. Off-site clean fill can only be employed for grading with prior EPA approval.
- Abandoning (pull casing and seal with grout), prior to construction of cap, leachate monitoring wells LF01, LF02, and LF03.
- Closing and abandoning, prior to pre-final construction inspection, monitoring wells MW-West, MW-South and MW-East. All well abandonment and closure shall be in accordance with Michigan Act 315.
- Tree removal/conservation. Where possible, existing trees outside of the landfill cap area will be preserved.

The Group has proposed technical equivalents to the ROD and SOW requirements related to grading materials, cover system materials (drain layer) and the landfill gas system (venting wells and gas collection layer). The proposed modifications are detailed in Section 3.3.

Monitoring Program

Monitoring programs will be designed and implemented to evaluate and ensure that the construction and performance of the remedial action comply with approved plans and design documents. The programs consist of:

- A groundwater monitoring program to detect changes in the chemical concentration of the groundwater at and adjacent to the site following completion of the remedial action.

- An air monitoring program to detect air emissions from the landfill during the remedial action.

Contingent Remedy

A contingent remedy may be required at a later date to address groundwater. Five years after the completion of the landfill cap, a statistical test shall be completed on data from wells where the arsenic concentration has exceeded the MCL (0.05 mg/l) at any time during the monitoring period. The SOW requires a contingency remedy be implemented if:

- The statistical test results show that arsenic concentrations will not decline below 0.05 mg/l within 15 years of landfill cap completion, and/or
- The groundwater plume affected by the landfill threatens to raise arsenic concentration in a residential well that existed on the day the ROD was signed to levels above 0.05 mg/l.
- Preparation of a work plan, conducting pilot tests, designing and installing an in-situ groundwater oxidation system capable of restoring groundwater to performance standards will be required if any of the wells fail the statistical test. The contingent remedy description and requirements are further detailed in the ROD and the SOW.

The groundwater treatment system will be included in the contingent remedy and shall consist of a network of wells designed to increase oxidation of all contaminated groundwater that exceeds the MCL for arsenic to result in arsenic precipitation from the groundwater.

Groundwater treatment shall continue in each well designated for performance monitoring until the MCL performance standard for arsenic (0.05 mg/l) is attained. If no wells fail the statistical test for arsenic concentration, and the groundwater plume does not threaten residential wells, a contingent remedy will not be required; however, groundwater monitoring shall continue for at least five years following attainment of the arsenic performance standard.

This Section presents the remediation action design criteria based on Applicable or Relevant and Appropriate Requirements (ARARs) and SOW requirements. A summary of these requirements is presented in Table 3-1. Detailed discussions of ARARs were presented in the Final Presumptive Remedy Feasibility Study Report (WW Engineering and Science, September, 1994) and the Record of Decision.

3.1 KEY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Key ARARs are summarized as action, chemical and location specific.

3.1.1 Action Specific

Resource Conservation and Recovery Act (RCRA)

RCRA Subtitle C requirements are relevant and appropriate to the portion of remedy involving off-site treatment of drummed waste with hazardous characteristics. RCRA subtitle D (40CRF Subtitle D Part 258) are appropriate to the cover system.

Michigan Environment Response Act (Act 307) -- Michigan Admin Code R. 299.601 et. seq.

Act 307 requirements are relative and appropriate with respect to Type C cleanup. Type C cleanup requires long term monitoring to assess the effectiveness of on-site containment of hazardous substance.

Solid Waste Management Act (Act 641) -- Michigan Code R. 299.401 et. seq.

Parts 3 and 4 requirements are relevant and appropriate to cover system, gas control and groundwater monitoring.

Clean Air Act (CAA)

New Source Performance Standards (NSPS) Title III applies if emissions from the site reach threshold limits of 10 tons per year hazardous air pollutant or 25 tons of any combination.

Michigan Air Pollution Act (Act 348) -- Michigan Admin. Code R. 336.1901 et. seq.

Act provides for fugitive dust and emissions control during and following construction.

Occupational Safety and Health Act (OSHA)

OSHA 29CFR1910 requirements are applicable to work at the site to protect the health and safety of workers.

Michigan Soil Erosion and Sedimentation Act (Act 347)

Act 347 requirements are applicable to any earth changes within 500 feet of a lake or stream.

Michigan Comp. Laws Ann. Section 257.722 ("Frost Laws")

"Frost Law" requirements are applicable to off-site activities on Michigan highways.

3.1.2 Chemical Specific

Safe Drinking Water Act (SDWA)

Act requirements are relevant and appropriate to groundwater remedies at the site.

3.1.3 Location Specific

Executive Order on Flood Plain Management Exec. Order No. 11.988; 40CFR6.302(b)

Executive Order No. 11.988 requirements are applicable for those portions of the selected remedy and contingent remedy that occur in the flood plain.

Executive Order On Protection of Wetlands Exec. Order No. 11.900; 40CFR6.302(a)

Executive Order No. 11.900 requirements are applicable where portions of the selected remedy and contingent remedy have potential to impact wetlands.

Endangered Species Act 16 USC.1531 et. seq.; 50CFR Part 200, 50CFR part 802

Act requirements are not applicable. No endangered species are present on the site.

3.2 EXISTING CONDITIONS

The landfill surface has significant areas with slopes below minimum requirements for closure. The surface has poor vegetation with brush and small trees. The landfill has minimal cover material (RI indicates one to four feet) consisting of on-site silty sand with gravel soil material mixed with debris in some locations. Debris and other junk materials are scattered over the surface.

Waste extends beyond the property boundaries to the east and south and to the boundary on the west. A security fence was installed beyond the extent of waste and property line during the RI.

3.3 EVALUATION OF ALTERNATIVE MATERIALS AND DESIGN ELEMENTS

The SOW and Feasibility Study described specific designs and materials for certain elements of the closure construction:

- Grading Materials; "Respondents may only use off-site materials for fill if those materials are approved by U.S. EPA, in consultation with MDNR, prior to use" (SOW, pg. 2, U.S. EPA, 1995)
- Cover System Materials, Drain Layer; "A 6 inch sand drainage layer or technical equivalent... The drainage layer will be composed of sand no coarser than 3/8 inch, with a minimum hydraulic conductivity of $1x10^{-2}$ cm/sec or synthetic material with a transmissivity of at least $3x10^{-5}$ m^2/sec." (ROD, pg. 25, U.S. EPA, 1994)
- Landfill Gas System, Gas Collection Layer; "...the cap will consist of a 12 inch sand gas collection layer on top of existing waste mass ..." (ROD, pg. 25, U.S. EPA, 1994).

- Landfill Gas System, Venting Wells; "... a system of venting wells may be constructed across the landfill to vent landfill gas to the atmosphere. The gas collection or venting wells will be constructed to collect gas from the entire area and depth of the landfill." (ROD, pg. 25, U.S. EPA, 1994)

Borrow sources have been identified on/or adjacent to the site for enough soil material to significantly reduce requirements for importing soil material for closure construction. These materials, however, will not meet arbitrary materials specifications described above.

In addition, Pre-Design Studies (recently approved) have shown that an active gas collection and treatment system is not required for the site. Therefore, it is prudent to re-evaluate the approach of using vertical gas vent wells for the passive gas venting system.

Elements of closure design and construction materials evaluated include:

- Grading Materials.
- Cover System Materials.
- Passive Gas Venting System.

The objective of this design modification request is to fully utilize on-site soil materials. Environmental impacts to the site from the truck traffic associated with the importing of material involve issues of road damage, congestion, dust and noise. The two roads most likely to be used for the transporting of this material would be Erie Road and State Route 99. Access from State Route 99 will require an easement from the property owner on the north end of the site. In addition, use of on-site materials will reduce the project schedule's dependence (winter or spring road restrictions) on importation of materials.

3.3.1 Grading Materials

"Respondents shall grade the landfill to attain grades and slopes required to facilitate drainage contours approved in the Remedial Design (RD). Respondents may only use off-site and to meet ARARs. Respondents may regrade the landfill as necessary to achieve sub-cap materials for fill if those materials are approved by U.S. EPA, in consultation with MDNR, prior to use." (SOW, pg. 2, U.S. EPA, 1995)

Much of the landfill surface currently does not meet minimum slopes required by MDEQ solid waste regulations. One method to achieve these grades is to import soil material to grade the landfill surface with the required two (2) percent slopes. Preliminary calculations indicate approximately 41,000 cubic yards (in place) would have to be imported for this purpose.

It is alternately proposed to consolidate sufficient amounts of waste from the east perimeter of the landfill area to achieve the minimum required slopes. It is also proposed to use borrow material from or adjacent to the site to place the daily cover and gas collection/foundation layer. Waste consolidation and on-site materials will replace the imported materials significantly reducing rough grading costs and significantly reduce truck traffic and associated environmental impacts and schedule constraints.

3.3.2 Cover System Materials

The ROD indicates specific design criteria/specifications for the drain layer. Materials to be used for the six (6) inch thick drainage layer that lies directly above the FML in the landfill cap section shall be "a sand that has a particle size less than 3/8-inch in diameter and a minimum permeability of 1×10^{-2} cm/sec. Minimum requirements for a synthetic alternative to the sand drainage layer are a transmissivity of 3×10^{-5} m^2/sec". Review of MDEQ Waste Management Division, Act 451, part 115 (formerly Act 641) indicate these design criteria are for the drain layer portion of a leachate collection system above a landfill cell liner and not for a cover drainage layer.

Further review of MDEQ Waste Management Division Rules, indicates that final cover system shall "Provide for the lateral drainage of precipitation off the cover of the landfill. The owner or operator may use permeable soil, geosynthetic drainage material, or a combination of both to provide such drainage..." (Act 451, part 115, Section R299.4425, Rule 425, Subpart 2(b)(i)(A)).No specific specifications are provided in the Act.

A combination of on-site materials and geosynthetic materials will be evaluated as the "technical equivalent" of the 6 inch sand drainage layer prescribed by the ROD. Specifically the use of on-site granular soils with an approximate hydraulic conductivity of 2×10^{-4} combined with strip drains to provide a free drainage flowpath is proposed. Strip drains are a 1-1/2 inch x 16 inch waffled HDPE wrapped in filter fabric that are positioned perpendicular to the slope to freely flow infiltrated stormwater from the cover system materials. Spacing of these strip drains is designed to control the intermittent saturated depth of cover system from infiltrated stormwater (following a storm event) to less than 16 inches. Utilizing on-site materials coupled with synthetics would eliminate the need to import sand and greatly reduce truck traffic and associated environmental impacts and schedule constraints. In addition, using alternative materials will provide a minimum working lift of one (1) foot above the FML providing adequate protection of the FML during construction with traditional low ground pressure dozers. Attempting to spread a six (6) inch drain layer on an FML could potentially cause significant damage to FML.

3.3.3 Passive Gas Venting System

The Pre-Design Studies (WCC, 1996) determined that an active gas collection and treatment system is not required. The ROD then requires the cap to include "a 12 inch sand gas collection layer on top of existing waste mass" and "a system of venting wells constructed across the landfill to vent landfill gas to the atmosphere. The gas venting wells will be constructed to collect gas from the entire area and depth of the landfill".

Act 641, Rule 425 requires the final cover to have either of the requirements of R299.443: (a) a permeable soil layer which is not less than 1 foot thick and which is located directly below the infiltration layer that vents gas to gas risers, (b) other means of assuring that gasses cannot travel laterally from the site or accumulate in structures.

The ROD and FS describe a passive gas venting system composed of a permeable gas venting layer 12 inches thick combined with 15 vertical gas vent wells with risers. This system will only provide approximately 450 feet of piping with atmospheric pressure to vent the entire landfill. It is proposed to utilize horizontal vent wells to vent the entire area and depth of the landfill.

Lateral spacing to the horizontal vent wells at 190 feet with risers every 200 feet provide over 2300 feet of pipe with atmospheric pressure to vent the landfill. Maximum travel distance for landfill gas to piping with atmospheric pressure using vertical vent wells is 141 feet while the maximum distance for horizontal vent wells is 105 feet

3.3.4 Conclusions

In summary, concurrence on use of the following alternative design and construction materials is requested:

1. Use of consolidated waste and on-site borrow materials for grading site to minimum slopes.
2. Use of on-site soil materials in conjunction with strip drains as a technical equivalent of drain layer.
3. Use of on-site granular permeable soils and horizontal vent wells and risers to meet landfill gas control requirements.

The combination of on-site borrow sources and use of alternative designs could reduce truck traffic from an estimated 4,000 trips to the minimum traffic required for mobilization, synthetic materials and topsoil materials. This will substantially reduce environmental impacts of construction, schedule constraints imposed by truck traffic and overall project costs.

3.4 DRUM REMOVAL

Steel drums located in TP-9 Area or discovered during other closure construction work will be relocated to a drum staging area. The drums will be sampled and analyzed to determine disposal method. Those drums with hazardous materials will be transported off-site for disposal or treatment. Other non-hazardous drums will be crushed and placed in the landfill fill area. Sampling, analysis, off-site transportation and disposal will be consistent with RCRA Subtitle C requirements.

3.5 WASTE CONSOLIDATION AND SITE GRADING

Site Grading design criteria are:

- Minimum 4% slopes
- Maximum 25% slopes

Waste consolidation design criteria are:

- Remove all visible waste and stained soils
- Consolidated waste compacted in 2 foot lifts with trash compactor
- 6 inch daily cover applied to consolidated waste
- Waste consolidation activities conducted under Health and Safety Plan consistent with OSHA 1910.120 requirements with action levels at the perimeter exclusion zone of less than 5 ppm VOC emission and less than 10% of the LEL.

3.6 PASSIVE GAS CONTROL SYSTEM

Passive Landfill Gas Control design criteria/objectives are:

- Control lateral migration
- Prevent accumulation of landfill gas
- Collect gas from the entire area and depth of the landfill

3.7 COVER SYSTEM COMPONENTS

The following design criteria have been developed to meet Act 641 and SOW requirements and meet engineering practice standards.

Gas Venting/Foundation Layer

The foundation layer serves as a separation layer between the waste and the barrier layer. This permeable layer also must be vented to prevent accumulation of gas and accompanying uplift pressures to barrier layer. Design criteria for this layer are:

- Granular permeable soil materials for gas venting
- Rounded particles no larger than 1-1/2 inch diameter from FML foundation
- Compacted to 90% of standard proctor
- Proof rolled to show absence of void spaces.

Flexible Membrane Liner

Michigan Act 641 and SOW requires installation of FML barrier layer. Design criteria are use of Linear Low Density Poly Ethylene (LLDPE) geomembrane with minimum thickness of 40 mil. Textured or smooth LLDPE will be used depending on slope stability analysis. LLDPE was chosen because of its superior performance in landfill environments.

Drainage Layer

It has been proposed to use on-site granular permeable soil materials in combination with strip drains to provide subsurface drainage for the cover system. The strip drains would be secured in place onto the FML prior to placement of cover soil material. These strip drains will either discharge from the toe of the landfill cover or intercept drain pipes in the stormwater control berms. The cover soil section thickness will be increased 6 inches to 24 inches to provide similar protection to FML and meet Act 641 requirements.

Design criteria/objectives for strip drains and cover soil as they relate to lateral drainage are:

- Provide lateral drainage off the cover of the landfill (Act 641)
- Technically equivalent to sand drain layer

Cover Soil

Michigan Act 641 requires a layer of cover soil eighteen (18) inches thick (not including 6 inch topsoil layer) between drain layer and vegetative top soil layer to protect the barrier layer from erosion. Design criteria for the cover soil layer are soil materials free of deleterious materials with no greater than six (6) inch particle size placed eighteen (18) inches thick over drain layer material.

Top Soil/Vegetative Layer

Michigan Act 641 and SOW require a six (6) inch thick topsoil layer capable of sustaining vegetative growth. Topsoil design criterion are: more than 3% organic matter; silty clay loam soil with particle size less than three (3) inches; and sufficient plant nutrients to propagate and sustain vegetative growth.

Vegetative seed mix will include native grass varieties as identified in the Pre-Design Studies Report (Woodward-Clyde, December 1996).

3.7.1 Stormwater and Erosion Controls

Michigan Act 641 requires the installation of a run-on and run-off system capable of collecting and controlling water volume resulting from at least a 24-hour, 25-year storm event. The system shall be capable of preventing hazardous waste or its constituents from escaping into the soil, surface water bodies, groundwater, or sewer and drains.

Michigan Act 641 limits erosion to not more than 2 tons per acre per year.

Michigan Act 641 requires the implementation of erosion control measures, as necessary, to comply with the provisions of Act 347 which apply to cap construction activities. Design criteria include design of cover system, stormwater control berms, perimeter stormwater control system to prevent run-on and control run-off from a 24 hour, 25 year storm.

3.8 FLOODPLAIN

No design criteria have been identified relating to floodplains since no remedial action construction activities are planned within a floodplain and hazardous wastes are not anticipated to be managed within a 100-year floodplain as designated in Figure 27 of the Final Remedial Investigation Report (WWES, 1994)

Some monitoring wells are located in the flood plain but will not affect flood plain characteristics. Should contingency action be implemented, Design Criteria will be developed to eliminate potential impacts to flood plain.

3.9 WETLANDS

There has been no design criteria identified for wetlands as the remedial action will not impact any wetlands and there have been no wetlands identified within the remedial action area. All stormwater will be controlled on site with infiltration basins. Some wetland habitat contiguous to the North Branch of the Kalamazoo River exists. However, the remedial action will not impact this area which is across E. Erie Road. Should the contingency action be implemented design criteria will be developed to eliminate potential impacts to nearby wetlands.

3.10 ENDANGERED SPECIES AND FAUNA

The Endangered Species Act (16 USC. 1531 et. seq. and 50 CFR Part 200 and Part 402 do not apply because no endangered or threatened species exist on the ASTL Site (Final Presumptive Remedy Feasibility Report, WWES, September, 1994).

TABLE 3-1
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) SUMMARY FOR ALBION-SHERIDAN COVER DESIGN

DESIGN FEATURE	REGULATION/RULE	REQUIREMENT
Site Grading	Michigan Act 641	Final Grades: - Min. 4% - Max. 25%
	Michigan Air Pollution Act 348	Rule 371 requires fugitive dust control
Drum Removal	SOW	Sampling, Analysis, Transportation and Disposal Activities to meet subtitle C requirements
Site Security	SOW	Six foot chain link with three-strand barbedwire Encompass waste (as a minimum) Post warning signs at 200-foot intervals
Waste consolidation	Michigan Act 641	Placement of Waste: - in compliance with landfill operation requirements - 6 inches daily cover - compacted in 24 inch lifts.
Stormwater Management Erosion Control	Michigan Act 641	Control stormwater from 24 hour 25 year storm Requires a layer to protect from wind and water erosion Erosion < 2 tons/acre/year
	Michigan Soil Erosion and Sedimentation Act, Act 347	Earth Changes: - > 1 acre - 500 feet from a lake or stream
	Rule 323.2190(a)(b)	Erosion Control for activities: - > 5 acres
Cover System Components	Michigan Act 641	Top Soil: - 6-inches thick - Capable of supporting vegetation

DESIGN FEATURE	REGULATION/RULE	REQUIREMENT
Cover System Components (cont.)		Common Fill/Protective Soil Layer: **- provide laterial drainage** - 24 inches thick Cap Liner: - 6 inches thick sand - Minimum permeability of 1×10^{-2} Liner Cap - Minimum 40 mil LLDPE FML
Gas Collection and Venting System	Michigan Act 641, Rule 299.4425 (b)(a)(b)	Gas Venting System: - 1 foot or greater soil layer - gas risers - no lateral travel or gas accumulation
Stability Control	Michigan Act 641 Rule 299.4425(9)	Stabilize Cover with: - soil type - slope - moisture content
Groundwater Monitoring and Analyses	SOW	Quarterly Monitoring: Annual Monitoring Residential Monitoring 5 Year Review Monitoring
General Operation and Maintenance	40 CFR 264.117(a)(1	Post Closure Care: - begins after completion of closure

This section presents the landfill design elements related to closure of the landfill based on the applicable or relevant and appropriate requirements (ARARs) and SOW requirements outlined in the previous section. An overview of each design element will be presented to establish a basis of design and depict the characteristics of the design components. The elements to be discussed are as follows:

- Area Drum Removal and Disposal
- Waste Movement and Site Grading
- Passive Landfill Gas Control
- Landfill Cover System
- Design Analysis
- Location of Construction Activities

4.1 AREA DRUM REMOVAL AND DISPOSAL

Based on the test pit excavation completed by ABB Environmental Services on June 7 through June 9, 1994, a confirmed fill area of drums is located on site. This element of the project must be addressed in the cover system grading plan and be given priority in the project construction schedule.

Consideration for the drum removal and disposal has been incorporated into the design in areas such as delineating the exclusion (work) zone area for excavation, providing a staging area for drum overpacking and outlining procedures and materials to be utilized in the removal, sampling, evaluation, overpacking, transport and treatment or disposal of the drums removed.

4.2 WASTE MOVEMENT AND SITE GRADING

As it currently exists, the landfill waste disposal area is relatively flat on the main part of the fill and has steep side embankments located on a majority of the edges. Some of the waste has been placed on properties adjacent to the landfill. Trees and surface debris litter a large portion of the site.

Prior to initiating any site grading activities, the entire site will be stripped of existing surface vegetation and debris. Cut materials, which will include some surface waste materials, will be placed within proposed fill areas on the main fill area and compacted. Any large trees will be processed through a chipper prior to placement. On-site soil material will be placed on top of the stripped material on an as needed basis for a working cover to discourage any fugitive transport of waste off-site.

In order to meet the minimum slope requirements set by the Michigan Department of Environmental Quality (MDEQ) Rules (discussed in Section 3 of this report) and to support positive stormwater drainage, fill must be placed on the landfill surface and graded. Moving the waste from the eastern property boundary toward the interior of the main fill providing a 100 foot buffer for site access and stormwater drainage will also create sufficient grading material to achieve four (4) percent minimum slopes. The slopes along all sides of the landfill will be graded to a maximum of 4 (horizontal) to 1 (vertical). A minimum of six (6) inches of soil cover material will be placed over all relocated waste upon completion of grading which will provide cover to reduce odors and discourage any transport of waste off-site.

Design grades for interior and perimeter stormwater drainage flowlines range between 2 to 4 percent. These grades are controlled by existing site topography, outlet elevations and final landfill cover elevations.

Excavated material from proposed stormwater retention basins will be utilized for on-site soil borrow during the cover construction and coordinated with the perimeter stormwater drainage design to create retention/infiltration basins. This will eliminate any off-site discharge of the landfill stormwater runoff to surrounding roadside ditches and properties.

Final site grading will include a site access road in compliance with MDEQ Solid Waste Rules situated around the perimeter of the completed cap area. Access will also be provided to the crest of the cap for any future operations and maintenance activities. The access road will consist of a twelve (12) inch thick gravel layer twenty (20) feet wide placed on top of the cover soil layer. The perimeter road has a one (1) per cent cross grade to provide drainage from the gravel surface to the flowline and avoid ponding.

4.3 PASSIVE LANDFILL GAS CONTROL

The passive landfill gas control system for the site serves the purpose of the following items:

- Prevent gas (uplift) pressures under the FML cover system.
- Prevent vertical and horizontal migration of landfill gases from the landfill cover area.
- Vent gas to the atmosphere at levels which do not exceed a total cancer risk of $1x10^{-6}$ at the site fenceline.

Site passive gas collection and venting system are designed based on the design analysis as discussed in Section 4.5 of this report. The horizontal passive gas vent well design includes the following components:

- Perforated High Density Polyethylene (HDPE) pipe placed within a washed stone packed trench excavated into the waste a minimum of four (4) feet.
- Vertical vent risers connected to the horizontal passive vent wells located on crest of the landfill slope spaced approximately 190 feet apart from north to south across the site.

4.4 COVER SYSTEM

The final landfill cover system contains individual components that perform a specific function in the overall performance of the landfill cover. Some of the functions considered in the design of the cover system include the following:

- Vegetative support.
- Erosion control.

- Drainage.
- Separation.
- Frost protection.
- Minimizing surface water infiltration.
- FML protection.

Layers included in the final cover system design are outlined in the following sections and are supported by proper engineering analysis and documentation as required. The cover system components are described in the following sections from the bottom up.

4.4.1 Foundation Layer

The purpose of the twelve (12) inch thick foundation layer is to provide a buffer between the waste and the flexible membrane liner (FML) to prevent any objects located on the surface of the waste that may compromise the barrier material from coming into contact with the geosynthetic material. Soil material used for the construction of this layer will be an on-site silty sand material consisting of rounded rock particles less than one and a half (1-1/2) inches in diameter. The material will be placed and compacted in two (2) six (6) inch lifts to a density that is a minimum of 90 per cent of the standard proctor. The final surface will be graded and rolled to produce a smooth surface that will provide a good bedding surface for the FML ensuring adequate interface contact between the geosynthetic and soil.

4.4.2 Flexible Membrane Liner (FML)

Located above the foundation layer, the FML serves as the impermeable barrier to hydraulic infiltration and vertical gas migration for the cover system. The material to be used for this component is a 40 mil Linear Low Density Polyethylene (LLDPE) membrane. All seams will be overlapped and bonded together by heat fusion. Quality control testing will encompass the verification of the seams and overall quality of the material used.

Smooth surfaced FML will be used in all areas where the subgrade slope is less than 6 (horizontal) to 1 (vertical). The section of the cover system where the subgrade slope is anticipated to exceed 6 to 1 will be the tie in of the cover system to the perimeter surfaces. This section requires a textured FML to ensure slope stability on the 4 (horizontal) to 1 (vertical) slope.

4.4.3 Cover Soil

The cover soil component of the overall cover system functions in accomplishing the minimum FML frost and working protection required by MDEQ and geosynthetics manufacturers. This layer will be placed directly over the FML and will require an on-site soil material that is similar in composition to the foundation layer.

4.4.4 Topsoil/Vegetative Layer

Six (6) inches of topsoil will form the uppermost layer of the landfill cover system. This layer's primary function is to promote and sustain vegetative growth on the surface and concurrently control wind and water erosion. Proper fertilization and seeding of the 6-inch layer will yield sufficient vegetative growth that in turn will stabilize the surface of the cover system to provide long-term erosion protection. Flow lines that exceed two (2) percent slopes utilize a temporary erosion control mat which will limit erosion prior to full vegetation development. Topsoil material will be obtained from an off-site borrow source, as there is none available for use on the landfill site.

4.4.5 Stormwater and Erosion Controls

Stormwater from precipitation on the landfill site currently drains onto adjacent properties and infiltrates or sheet flows into highway ditches. No interior or perimeter drainage has been established on the existing landfill site.

To control and direct stormwater on the landfill cover system, three (3) foot high berms will be utilized. They require a flap of FML to be welded on the landfill impermeable membrane FML at a minimum two (2) percent grade perpendicular to the slope of the landfill. This flap is used for a back stop along the berm alignment for subsurface stormwater flow through the cover soil along the top of the impermeable FML. Perforated collection piping encompassed in a gravel pack wrapped in filter geotextile is placed up-slope from the berm flowline. Discharge of the berm and subsurface drain pipe is into the stormwater retention/infiltration basin created on the landfill property. The design for the stormwater and erosion controls for the cover system are based on the calculations outlined in Section 4.5.4 of this report.

4.5 DESIGN ANALYSIS

Supporting calculations and analysis for the 30% design were generated for several elements of the landfill closure. These analyses provide assurance that the landfill closure will perform its primary function of limiting infiltration while maintaining a high level of durability. Design calculations and analysis were performed in the following areas and are provided in Appendix A:

- Slope/FML stability.
- FML anchor trench depth/runout length.
- Soil loss from cover system.
- Stormwater runoff.
- Hydrologic Evaluation of Landfill Performance (HELP).
- Passive landfill gas horizontal well spacing.

4.5.1 Slope/FML Stability

The landfill cover system specified in the ROD and in this design utilizes a FML that consists of a LLDPE material placed on a layer of sand and is covered by another layer of sand and then topsoil. When this layered cover system is placed on a slope, the interfaces between the various material layers are subjected to shearing forces as a result of gravitational forces that tend to pull the upper portion of the soil mass to a more nearly level surface. A stability analysis model of the design cover system on the proposed maximum landfill cover slope is necessary to ensure an adequate factor of safety against slope failure is present.

The slope stability analysis was performed using two different exterior texture finishes for FML. On slopes that were less than 6 (horizontal) to 1 (vertical), a smooth FML was modeled, while surfaces less than 4 (horizontal) to 1 (vertical) were analyzed with a textured FML. Ottowa sand, a very clean medium-grained sand, was assumed to be the material placed in the foundation layer and the cover soil layer (each side of the FML). It is assumed that this will be a conservative assumption as the on-site material contains more silt and has been shown to have a greater soil/FML interface contact. Saturated conditions of the upper layers of the cover system were assumed to provide the model with a worst-case scenario.

Results of the analysis indicate that the smooth FML and the textured FML will adequately resist surface raveling failure along all cover system material interfaces. Factors of safety against failure range from 1.2 to 2.8. A factor of safety less than one (1.0) in the worst-case scenario assumed for the model (saturated soil conditions) would merit a re-design of the cover system and landfill slope configurations.

4.5.2 FML Anchor Trench Depth/Runout Length

Geomembrane (FML) covered landfill caps require the use of an anchor trench on the edges of the capped area to keep the geosynthetic in place. Tensile forces due to uplift from landfill gas pressures or from surcharge loading on the cover system are the components that cause the anchor trench to be a requirement in geosynthetic cover systems.

The anchor trench consists of an excavation that is made around the perimeter of the covered waste area to the required depth, laying the FML over the side and bottom of the trench and then backfilling soil over the FML to hold the material in place. The required depth of the trench is determined by considering all the forces and associated stresses that act upon the FML. A factor of safety is applied to the maximum tensile force the geosynthetic material can resist to provide accommodation for worst-case scenarios.

Utilizing a conservative factor of safety of 4.0, the results for the required anchor trench depth and runout length indicate the depth to be approximately 1.9 feet and the width to be 2.0 feet. This information will be reflected in the design drawings by the incorporation of an anchor trench configuration that is 2 feet deep by 2 feet wide.

4.5.3 Soil Loss From Cover System

To predict the performance of the designed cover system configuration and the landfill cap slopes, the soil loss due to erosion is modeled. This analysis estimates the amount of soil erosion by precipitation and stormwater runoff. The EPA guideline for the maximum allowed soil loss due to erosion is two (2) tons per acre of landfill surface.

The analysis completed for the soil loss performance of the landfill cover system included some assumptions as the exact soil types to be used for the cover system and final grading plan have not yet been determined. This led to conservative material and slope configurations that are reflected in the calculation provided in Appendix A. Ground cover conditions analyzed for the site included 80 percent and 95-100 percent surface cover scenarios. These cover scenarios are most applicable to post-construction and long term landfill cap conditions.

Results indicate the assumed worst case soil and slope configuration used for the analysis show the soil loss for the 80 percent ground cover and 95-100 percent ground cover conditions are less than the allowed maximum of two (2) tons per acre.

4.5.4 Stormwater Runoff

Stormwater runoff for the project site will be designed in compliance with requirements outlined in the MDEQ Act 641 Rules. Guidelines provided in these Rules, indicate the landfill cap stormwater drainage and site infiltration/retention basins must perform adequately to the 24 hour 25 year design storm event.

This analysis will be completed and submitted in a subsequent submittal upon approval of the finished grading plan and cover system and subsurface drainage configurations.

4.5.5 Hydrologic Evaluation of Landfill Performance (HELP)

This computer-based analysis was performed to predict the infiltration performance of the landfill cover system by taking into consideration the soil/material used in each layer. Meteorological data that is specific to the region of the site is synthetically fabricated by the HELP program for the number of years specified creating a well-rounded model that accounts for most elements of cover system hydrologic performance.

As indicated in Appendix A, five (5) and twenty-five (25) year storm events were analyzed for the design cover system. FML pinhole densities and FML installation defects were assumed to be relative to good installation quality. It was believed that with proper site construction QA/QC with experienced inspection personnel that this quality could be easily achieved.

The HELP analysis for both precipitation events indicated no percolation/leakage through the FML layer. Average water head across the FML layer (based on peak daily values) shows less than one (1) inch of accumulation.

4.5.6 Passive Landfill Gas Horizontal Well Spacing

To provide a basis for the spacing of the passive landfill gas horizontal vent well spacing calculations (Appendix A) were performed to model the flow length required to effectively collect and vent the landfill gas produced under the final cover system. The analysis was based on proven convective gas flow mechanisms and Darcy's equation assuming laminar flow. Typical landfill parameters cited in several literature sources were substituted in the analysis as site specific information was not available in the previous investigative studies performed for the site. The flow length equation derived from Darcy's equation utilized the following input parameters:

- Refuse permeability.
- Depth ratio (saturated gas flow depth versus depth of refuse).
- Specific weight of landfill gas.
- Landfill gas production rate.
- Landfill gas pressure.
- Refuse density.
- Atmospheric pressure.

Results of the analysis provided a flow length of approximately 95 feet. Because landfill gas will flow to a horizontal vent well from both directions within the interior of the landfill, the spacing of the vent wells will be twice the gas flow length. This provides a spacing guideline for the horizontal vent wells in the interior of the landfill of 190 feet.

4.6 LOCATION OF CONSTRUCTION ACTIVITIES

Various areas of the site and adjacent properties will be utilized during the construction phase of the project. These areas must be considered during the design process with respect to preservation of completed areas and areas sensitive to equipment traffic after completion of a designed closure component. The areas that will be addressed in this section include three major areas of the landfill construction as follows:

- Contractor staging/material storage
- Landfill closure activities
- Material borrow sources

4.6.1 Contractor Staging/Material Storage

The contractor selected for the construction phase of the project will require mobilization of equipment and materials to the site for the landfill closure. An area is needed to store equipment and materials as well as provide an area for employee parking and field offices. The area that is to be used in this capacity is the south end of the site bordering Erie Road. This will allow for easy transport and drop off of materials and equipment to the site and provide easy access to the cap areas where the equipment and materials will be used. If needed, additional staging area on the north side of the site may be used. This would encompass the proposed material borrow area/stormwater infiltration basin.

4.6.2 Landfill Closure Activities

The landfill construction activities will encompass the entire 18 acre site from the initiation of the remedial action. This will begin with the stripping and grubbing of the landfill area and continue with waste relocation efforts, passive gas system installation, followed by cover system placement and establishment of all access and stormwater controls. Based on the site design, these activities are able to be coordinated to ensure an efficient and quality closure.

4.6.3 Material Borrow Sources

The design indicates one soil material borrow source for the site that will be utilized for construction of the landfill cover system. Excavation activities will be located on the northern section of the landfill property and can also be considered as part of the stormwater control system construction. Depending on the soil quantities needed for the final cover system and the amount available on the north end (as determined in the final design), borrow activities could carry over to the south end of the landfill along Erie Road.

This section briefly discusses the elements that will be submitted for the remedial action at the preliminary design and final design stages. Items outlined in this section are as follows:

- Design Drawings.
- Technical Specifications.
- Design-Build Contract and Conditions.

5.1 DESIGN DRAWINGS

Preliminary design drawings for the remedial action outline several components of the project. The following is a list of drawings that have been developed for the preliminary design submittal:

Drawing Number	Drawing Description
1	Location Maps and Drawing Index
2	Existing Site Conditions
3	Grading Plan
4	Cover System Sections and Details
5	Stormwater Control Plan
6	Stormwater Control Sections and Details
7	Passive Landfill Gas Control Plan
8	Passive Landfill Gas Control Sections and Details
9	TBA
10	TBA
11	TBA

The drawings listed above are attached to this report. Sheets 9-11 are reserved for further development of the design. Sections and details of the cover system and finished grade necessary for construction are intended to be detailed on these sheets. Revised drawings will be submitted with the 95% and Final Design Report.

5.2 TECHNICAL SPECIFICATIONS

Specifications are required for the various landfill components of the remedial action implementation. The purpose of the specifications is to provide information to the contractor on quality, type and performance issues associated with the various contents of the work. The following is a preliminary list of sections to be included in the specifications to be developed for the final design of the project:

Specification Section	Description
01011	Summary of Project
01039	Progress Meetings
01052	Pollution Control
01400	Quality Assurance and Quality Control
01450	Health and Safety
01500	Mobilization and Temporary Controls
02110	Clearing, Stripping and Grubbing
02115	Site Preparation
02211	Waste Excavation and Handling
02220	Earthwork
02235	Filter Fabric
02715	HDPE Pipe
02725	Removal of Surface Water, Control of Runon and Runoff
002778	Geomembrane
02831	Chain Link Fence and Gates
02936	Seeding

This section identifies the properties related to the Remedial Action, any deed restrictions that will be imposed on the properties following completion of construction, easements that will be needed for construction and environmental monitoring, and applicable state, county and local permits required.

6.1 INTRODUCTION

Future development including, but not limited to, on-site excavation, construction and drilling shall be prohibited. The prohibition is achieved by filing with the Calhoun County recorder the restrictive covenants included in Appendix E of the UAO.

Institutional controls in the form of deed restrictions or a local ordinance shall be implemented 30 days after the approval of the pre-design studies report. The deed restrictions will prohibit the installation of any groundwater well which draws drinking water from the area noted in Figure 4 of the ROD to contain 2 ug/l of arsenic or more.

All restrictions regarding future development of the landfill shall be considered permanent. U.S. EPA may advise lifting the restrictions on future groundwater drinking water well installation when the arsenic concentrations in the groundwater area described in Figure 4 of the ROD remain below the MCL for two years.

6.2 DEED RESTRICTIONS

After completion of the Remedial Action, the property that contains the closed landfill area and groundwater monitoring systems will need to have deed restrictions in place to prevent future land uses that could damage the effectiveness of the completed project. These restrictions would involve such things as prohibiting the drilling of wells on the covered landfill and down-gradient properties, removal of perimeter security fencing and development of the capped landfill surface.

6.3 EASEMENTS

Easements for access to properties adjacent to the landfill property for the construction and post-closure monitoring phases will be needed. Reasons for the establishment of these easements for both issues is outlined in the following sections.

6.3.1 Environmental Monitoring

Groundwater monitoring wells are currently in place on properties adjacent to the north, south and west sides of the landfill site. Access to these wells for post-closure monitoring will require adequate access for sampling for all properties involved.

6.3.2 Construction

During the construction phase of the project, access will be needed to adjacent properties for a few reasons. One aspect involves the waste relocation from properties on the east side of the site. Foliage and soil will be removed in this process and slopes will need to be reconstructed.

The other aspect involves site construction equipment and material storage areas. This requirement will have to infringe on the current property boundaries as the landfill proper will be encompassed in waste relocation and grading activities for a majority of the construction period rendering it impossible for storage of equipment and materials on the site. There also will need to be space designated in this lay-down area for office trailers for the contractor, subcontractors and the site engineer. This activity may require the vegetation be removed and the ground surface graded level if needed.

6.4 PERMIT REQUIREMENTS

WCC contacted personnel at Calhoun County and MDEQ (air quality and surface water division) to establish specific local requirements for the construction of the project. The City of Albion was not contacted as the project location is outside city limits.

The county personnel indicated they would require a Erosion Control Permit for any project that would involve the disturbance of more than 1 acre of land or was conducted within 500 feet of a waterway. This permit would require the submission of an application with the final project plans attached for review by the county. The application will be completed by the contractor prior to the start of construction and the contractor will be held responsible for compliance of the permit conditions.

The air quality division of the MDEQ has several rules under Act 451 of 1994 that should be considered. Primarily, Rule 230 concerning Air Toxics from New and Modified Sources, would have to be met. The rule provides atmospheric discharge limits that must be met. These limits are based upon the same risk level as required by the SOW; therefore, the MDEQ concerns will be addressed if the SOW requirements are met.

Section 3.0 of the SOW requires the preliminary design submittal to address the preliminary construction schedule and includes a description of the contracting strategy for the Remedial Action. These items are summarized in the following sections.

7.1 CONTRACTING STRATEGY

The Group has taken a traditional (bid-build) construction contracting strategy into consideration at this time. This strategy will require approximately 60 days to complete contractor selection as the process involves the following tasks:

- Preparation of bid document.
- Client review.
- Revisions to bid document.
- Solicitation of construction bids.
- Contractor selection.
- Negotiation of construction contract.

After these items are addressed, a notice to proceed will be issued to the selected contractor and implementation of the Remedial Action will begin.

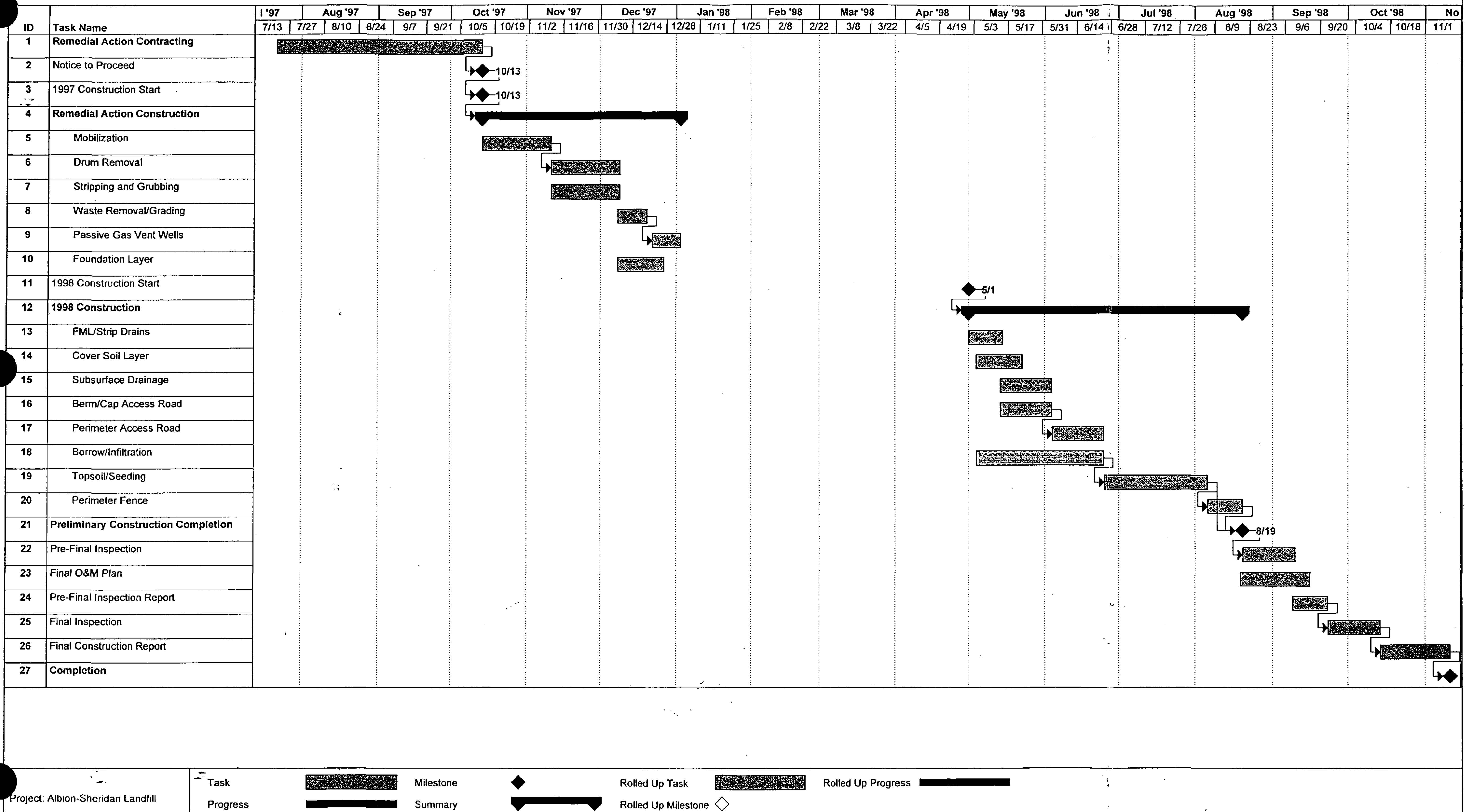
A design-build contracting scheme may also be considered by the Group for the implementation of the Remedial Action. This contracting arrangement would positively affect the construction schedule for the project by reducing or eliminating the Remedial Action contracting time.

The Group reserves the right to determine the proper contracting arrangement for the implementation of the Remedial Action and this decision will be reflected in a subsequent submittal.

7.2 CONSTRUCTION SCHEDULE

A project schedule for the Remedial Action is submitted as Figure 7-1 which outlines the preliminary construction schedule. This schedule reflects the major components of the construction for the site and the milestones as outlined in the SOW. The schedule represents the worst case scenario for the construction with the bid-build contracting strategy currently being considered. There would be a reduction or elimination of the Remedial Action contracting time if the contracting strategy reflected a design-build situation.

FIGURE 7-1
CONSTRUCTION SCHEDULE
ALBION-SHERIDAN TOWNSHIP LANDFILL



8.1 OVERVIEW

The Performance Monitoring Plan (PMP) will present pertinent background information and describe the methodology to assess the performance of drum removal and treatment, construction of the landfill cap and landfill gas collection systems, groundwater monitoring program, and, if implemented, the groundwater treatment system. Monitoring during remedial construction, such as for dust or air emissions, will be described in the project specifications and the health and safety plan and further detailed in the Contractor's health and safety plan that will be required by the Contract Documents and the RA Work Plan.

The PMP is found in Appendix B. Plans that will be provided that complement the PMP include:

- Construction Quality Assurance Plan (CQAP), - Section 9 and Appendix C.
- Contingency Plan (CP), - Section 10.
- Operation and Maintenance (O & M) Plan, - Section 11

The CQAP will address construction quality assurance sampling and analysis requirements to assure cap integrity. The CP will be complemented and further detailed in the Contractor's health and safety plan that will be required by the Contract Documents and the RA Work Plan. An initial O & M Plan will be submitted as a final Design Document prior to the pre-final construction inspection.

The purpose of the CQAP is to ensure, with a reasonable degree of certainty, that the completed Remedial Action meets or exceeds the requirements of the design criteria, the construction plans and the construction specifications. The plan will cover, at a minimum, the items listed in Section III of the SOW. A draft CQAP is presented in Appendix C.

The draft Contingency Plan which describes measures and procedures to be used in the event of an accident or emergency at the site are detailed below. The final Contingency Plan will be included in the health and safety portion of the Contract Documents. The plan is prepared in accordance with Section III of the SOW.

10.1 CONTINGENCY AND EMERGENCY RESPONSE PLAN

Before work commences at the site, The Contractor shall be required to develop contingency plans including evacuation procedures and routes to places of refuge or safe distances from the danger area, for the following potential emergencies:

- chemical exposure.
- personal injury.
- potential or actual fire or explosion.
- environmental accident (spill or release).
- discovery of radioactive material.

In the event of any emergency associated with remedial action, the Contractor shall without delay take diligent action to remove or otherwise minimize the cause of the emergency, alert the Engineer; and institute whatever measures might be necessary to prevent any repetition of the conditions or actions leading to, or resulting in, the emergency.

The emergency response and contingency plan for on-site and off-site emergencies, shall be prepared as specified in OSHA 29 CFR 1910.120(1), which shall address at a minimum:

- Name of person responsible for response in case of an emergency.
- Personnel roles, lines of authority, training and communication.
- Emergency recognition and prevention.
- Plan dates of meeting with local community, State and Federal agencies, and the local emergency squads.
- Site security and control.
- Evacuation routes and procedures.
- Decontamination.
- Emergency medical treatment and first aid.
- Emergency alerting and response procedures.
- Directions to the medical facility.
- Personal Protection Equipment (PPE) and emergency equipment (as in Section 1.10)
- Air monitoring Plan (from the design package).

In the event of any emergency, the Contractor shall without delay: take diligent action to remove or otherwise minimize the cause of the emergency. alert the Engineer, and institute whatever measures might be necessary to prevent any repetition of the conditions or actions leading to, or resulting in, the emergency.

Emergency medical care services shall be prearranged at a nearby medical facility with established emergency routes. The staff at the facility shall be advised of the potential medical emergencies that might result and that the patients clothing and skin may be contaminated.

The Contractor shall establish emergency communications with health and emergency services. The name of this facility, name of contact, emergency routes and emergency communications arrangements shall be posted at the site. The posted list shall include the following minimum points:

- Contractor physician name, address, and telephone number.
- Ambulance service and fire department telephone numbers.
- Procedure for prompt notification of Engineer and MDEQ.
- Location of emergency showers/eye lavages.
- Location of self-contained breathing devices.
- Specific procedures for handling personnel with excessive exposure to chemicals or contaminated soil.
- All emergency contact names and telephone numbers shall be posted at all project phones.
- All site support vehicles shall be equipped with route maps providing directions to the off-site medical facility. All drivers of support vehicles shall become familiar with the emergency route and the travel time required.

In the event that an accident or some other incident such as an explosion, a theft of any hazardous material, or an exposure to toxic chemical levels occurs during the course of the project, the Engineer shall be telephoned immediately and receive a written notification within 24 hours. The report shall include the following items:

- Name, organization, telephone number, and location of the Contractor.
- Name and title of the person(s) reporting.
- Date and time of accident/incident.
- Location of accident/incident, including site location and facility name.
- Brief summary of accident/incident giving pertinent details including type of operation ongoing at time of accident.
- Cause of accident/incident, if known.
- Casualties (fatalities, disabling injuries).
- Details of any existing chemical hazard or contamination.
- Estimated property damage, if applicable.
- Nature of damage; effect on contract schedule.

- Action taken be Contractor to insure safety and security.
- Other damage or injuries sustained (public or private).

An Operation and Maintenance (O & M) Plan will be prepared to cover long-term maintenance of the landfill cap, passive gas venting system and groundwater monitoring system. The O & M Plan will be prepared in accordance with Section III of the SOW. An overview of each of the components of the O & M Plan is presented below. The final O & M Plan will be submitted no later than the date of the Pre-Final Construction Inspection.

11.1 COVER SYSTEM OPERATION AND MAINTENANCE

The completed landfill cover system will be subjected to periodic inspections. Additional site visits may be warranted after large storm events. The inspection will address and verify the following items:

- A healthy, self sustained vegetative cover is present over the aerial extent of the cover.
- Survey the cover for signs of erosion, gullies or rills.
- Site drainage features to insure integrity and proper performance.
- Integrity of security systems.

11.2 GROUNDWATER MONITORING SYSTEM OPERATION AND MAINTENANCE

This section summarizes the O & M groundwater monitoring requirements for the ASTL site. Following completion of the landfill cap, groundwater monitoring will be performed as stated in the ROD and SOW. The O & M groundwater monitoring program is further detailed in the Performance Monitoring Plan (PMP) found in Appendix B.

11.2.1 O&M Objective

The purpose of the O&M groundwater monitoring is to assess the effectiveness of the remedial action/cap integrity by detecting changes in the chemical concentration of the groundwater at and adjacent to the site.

11.2.2 O&M Monitoring Well Locations

Specific existing groundwater monitoring wells and seven drinking water wells will be included in a quarterly O&M monitoring program. Also, existing (along with two wells yet to be installed) groundwater monitoring wells will be included in an annual O&M monitoring program. Additionally, designated groundwater monitoring wells will be included in a 5 year review monitoring program.

11.2.3 O&M Groundwater Sampling and Analysis Program

The groundwater monitoring wells will be sampled in accordance with procedures detailed in the PMP, Attachment A (expected to be similar to the procedures detailed in the RD Work Plan FSP

- WCC, 1995). However, It is anticipated that low-flow submersible pumps will be installed in each of the wells in the monitoring program.

The O&M monitoring and drinking water well quarterly and annual sampling/analysis events will commence following EPA and MDEQ approval of the final Construction Report.

The quarterly groundwater monitoring program will consist of: 1) field parameters, 2) arsenic, and 3) ammonia. Field parameters include: groundwater depth/elevation before purging (except for drinking water wells); temperature; pH; specific conductivity; Eh; and dissolved oxygen.

The quarterly monitoring of seven drinking water wells will consist of: 1) field parameters, 2) Special Analytical Services (SAS) low level organics, 3) SAS low level metals, cyanide, mercury (unfiltered), and 4) SAS parameters: chloride, sulfate, nitrate/nitrite, and ammonia.

The annual monitoring will consist of: 1) field parameters, and 2) chemicals of concern. Chemicals of concern will be 5 Target Analyte List (TAL) chemicals (Aluminum; Arsenic; Cobalt; Manganese; and Nickel), 2 Target Compound List (TCL) volatile organic compounds (VOCs) (Benzene and Vinyl Chloride, antimony, ammonia and 1,2-Dibromo-3-chloropropane.

Approximately 50 to 52 months after approval of the Final Design, designated monitoring wells will be sampled and analyzed for TCL organics, TAL inorganics and 1,2-dibromo-3-chloropropane to assist the EPA in meeting the requirements of Section 121(c) of CERCLA for the first five year review of the site.

11.2.4 Operation & Maintenance

O & M requirements of the dedicated bladder pumps will be as detailed by the manufacturer. O & M requirements of the field sampling equipment is detailed in Attachment A of the PMP.

11.3 PASSIVE GAS VENTING SYSTEM OPERATION AND MAINTENANCE

In concurrence with the landfill cap operation and maintenance, periodic site inspections will also be performed with respect to the passive gas venting system. The inspections will entail a visual examination of landfill gas emissions through sources other than the vent piping by looking for areas of wilted or brown patches of vegetation not consistent with surrounding vegetation. The same visual inspection will be used for the monitoring of off-site gas migration.

During the winter months, periodic site visits to check on the openings of the vent risers will be necessary. This will prevent ice from condensation from obstructing the riser pipe opening and continue design venting efficiencies.

DRAWINGS

PRELIMINARY (30%) DESIGN DRAWINGS

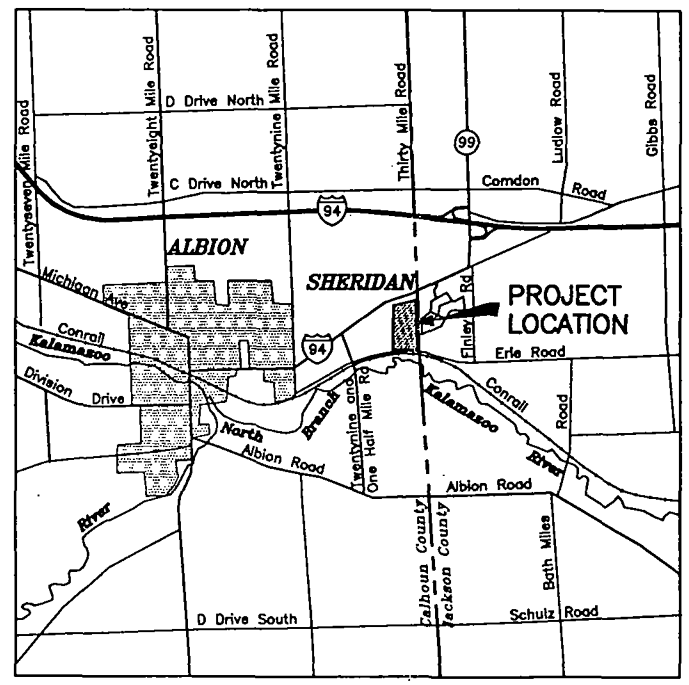
LANDFILL COVER SYSTEM

ALBION-SHERIDAN TOWNSHIP LANDFILL

CALHOUN COUNTY, MICHIGAN

LOCATION MAP

NOT TO SCALE



VICINITY MAP

NOT TO SCALE

DRAWING INDEX

DRAWING NO.	TITLE
1	LOCATION MAPS AND DRAWING INDEX
2	EXISTING SITE CONDITIONS
3	GRADING AND WASTE CONSOLIDATION PLAN
4	COVER SYSTEM SECTIONS AND DETAILS
5	STORMWATER CONTROL PLAN
6	STORMWATER CONTROL SECTIONS AND DETAILS
7	PASSIVE LANDFILL GAS CONTROL PLAN
8	PASSIVE LANDFILL GAS CONTROL SECTIONS AND DETAILS
9	PERIMETER FENCE PLAN AND DETAILS
10	RESERVED
11	RESERVED

PREPARED FOR
ALBION-SHERIDAN TOWNSHIP PRP GROUP
BY WOODWARD-CLYDE CONSULTANTS
MINNEAPOLIS, MINNESOTA

NOT FOR CONSTRUCTION

REV	DESCRIPTION OF REVISION	BY	DATE
△			
△			
△			
△			
△			
△			

I hereby certify that this plan, specification or report was perpared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the state of Michigan.

?

DATE

Woodward-Clyde Consultants
Engineering & sciences applied to the earth & its environment
Park Place West Building, Suite 660
6465 Wayzata Boulevard
Minneapolis, Minnesota 55426

WARNING
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

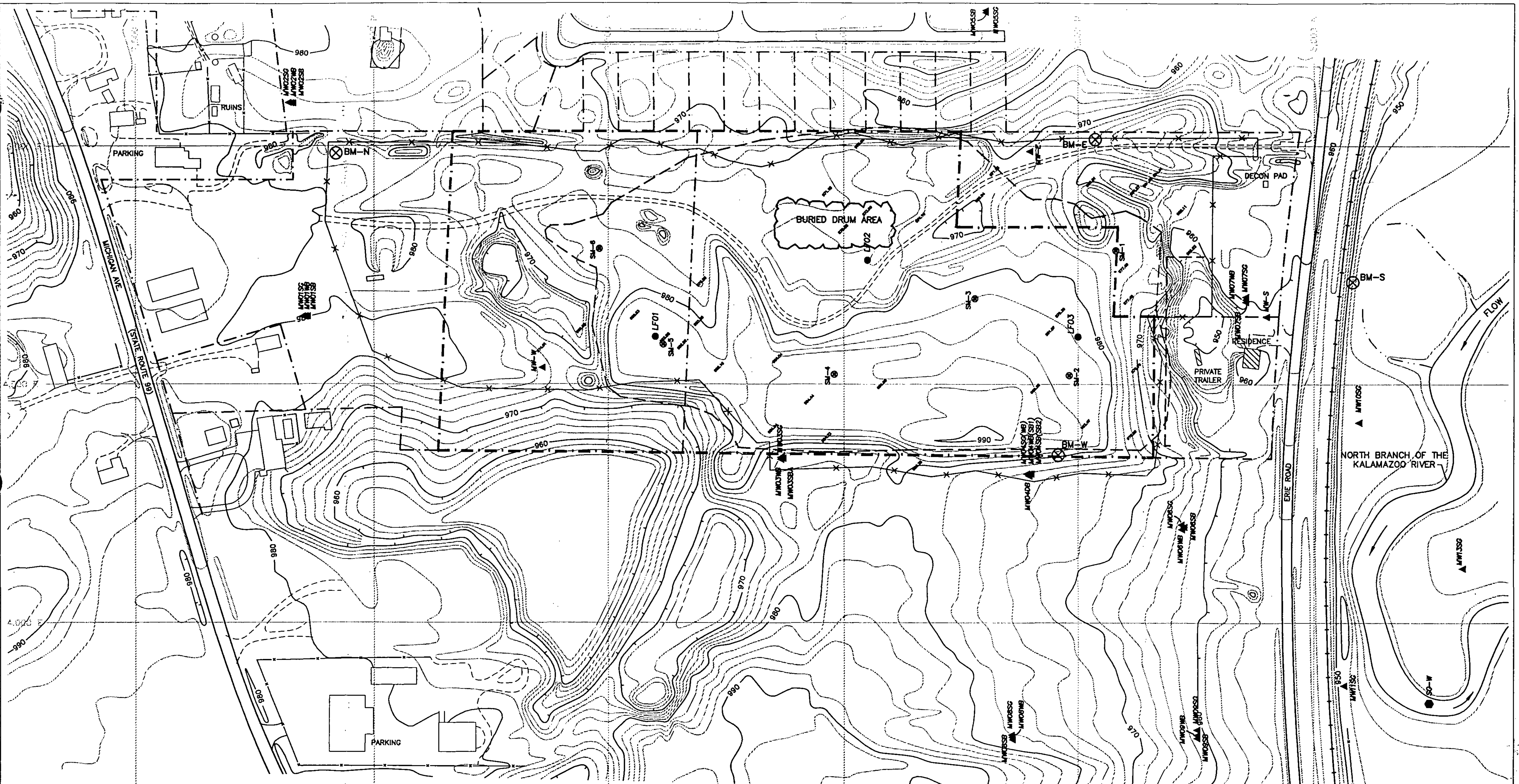
DESIGNED	RJ
DRAWN	SWH
CHECKED	LGH
PEER REVIEWED	RMC
PROJECT MANAGER	RGC
DATE	1/10/97

Albion-Sheridan Township Landfill — Albion, Michigan

LOCATION MAPS AND DRAWING INDEX
COVER SYSTEM

REVISION △
PROJECT 6E13045
DRAWING 1
SHEET 1 OF

FILE 3045-04 SCALE 1 SWH PROJ. TASK LOC. PROJ. SEND TO PHONE



GENERAL NOTES:

1. THE SITE IS LOCATED IN SECTION 36, TOWNSHIP ZS, RANGE 4W, CALHOUN COUNTY, MICHIGAN.
2. ALL TOPOGRAPHICAL INFORMATION BASED ON 199 AERIAL SURVEY COMPLETED BY
3. CALL 1-800-MISSDIG PRIOR TO EXCAVATION.
4. EDGE OF WASTE AS DEFINED IN 1996 WOODWARD-CLYDE PRE-DESIGN STUDIES REPORT.

NOT FOR CONSTRUCTION

PLAN
EXISTING CONDITIONS

100 0 100
SCALE IN FEET

LEGEND

- UNPAVED ROAD
- INTERMITTENT STREAM
- RAILROAD TRACK
- FENCE LINE
- 960 — TOPOGRAPHIC CONTOUR (10' INTERVAL)
- TOPOGRAPHIC CONTOUR (2' INTERVAL)
- SITE BOUNDARY
- PROPERTY BOUNDARY
- EXTENT OF WASTE
- BM-S — BENCH MARK
- SPOT ELEVATION
- MW10SG — GROUNDWATER MONITORING WELL
- SM-4 — SETTLEMENT MONUMENT
- LF01 — LEACHATE MONITORING WELL

REV	DESCRIPTION OF REVISION	BY	DATE
△			
△			
△			
△			
△			

Woodward-Clyde Consultants
Engineering & sciences applied to the earth & its environment
Park Place West Building, Suite 660
6465 Wayzata Boulevard
Minneapolis, Minnesota 55426

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

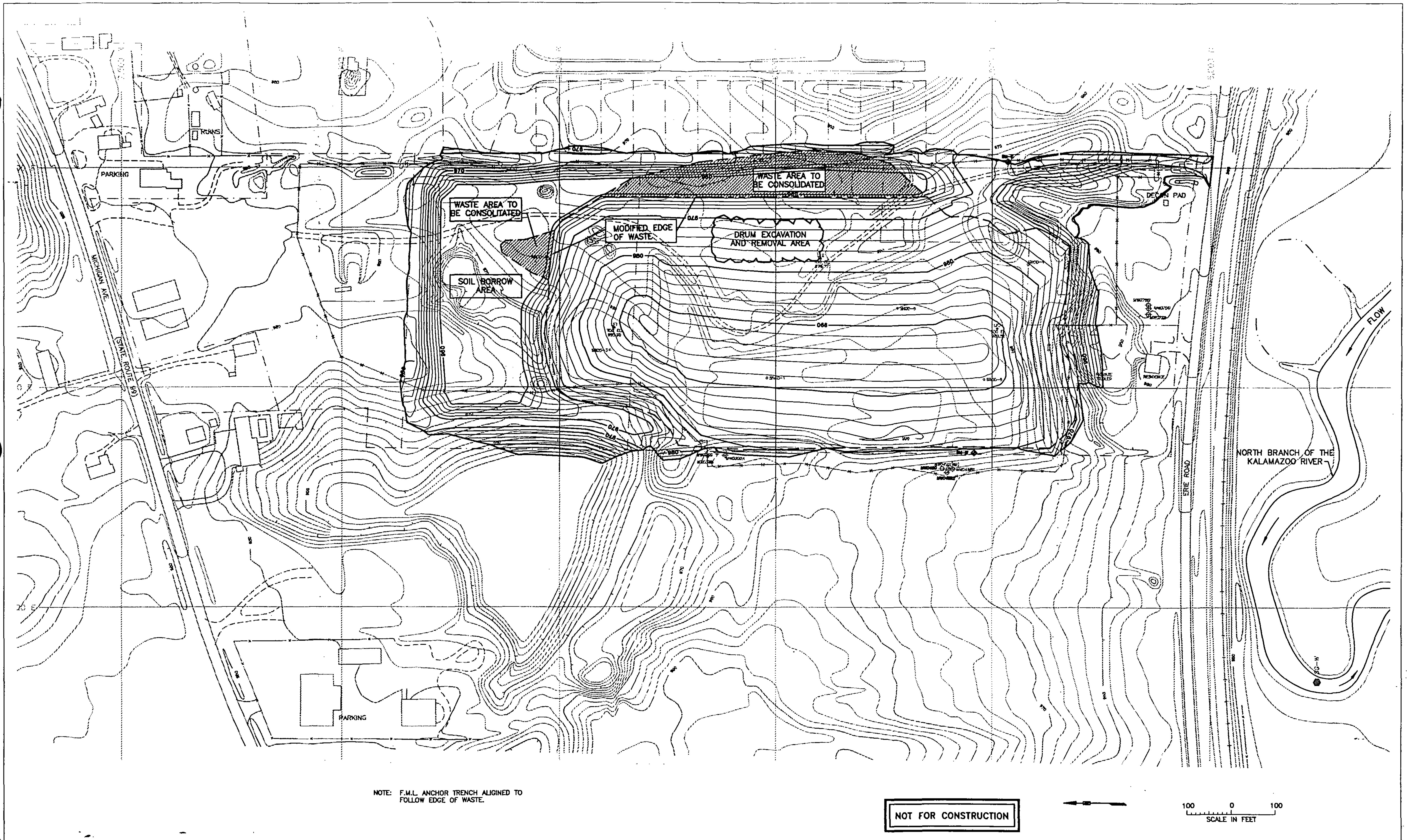
DESIGNED	RJ
DRAWN	SWH
CHECKED	LGH
PEER REVIEWED	RMG
PROJECT MANAGER	RGG
DATE	1/10/97

Albion-Sheridan Township Landfill — Albion, Michigan

EXISTING SITE CONDITIONS

REVISION △
PROJECT 6E13045
DRAWING 2
SHEET 2 OF

FILE 3045-01.DW SCALE 1:100 SWH 1/10/97 PROJ. 6E13045 TASK LOC. Mpls, Mn PROJ. ALBION SEND TO PHONE (612)593-5650



NOTE: F.M.L. ANCHOR TRENCH ALIGNED TO FOLLOW EDGE OF WASTE.

NOT FOR CONSTRUCTION

REV	DESCRIPTION OF REVISION	BY	DATE

Woodward-Clyde Consultants
Engineering & sciences applied to the earth & its environment
Park Place West Building, Suite 660
6465 Wayzata Boulevard
Minneapolis, Minnesota 55426

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

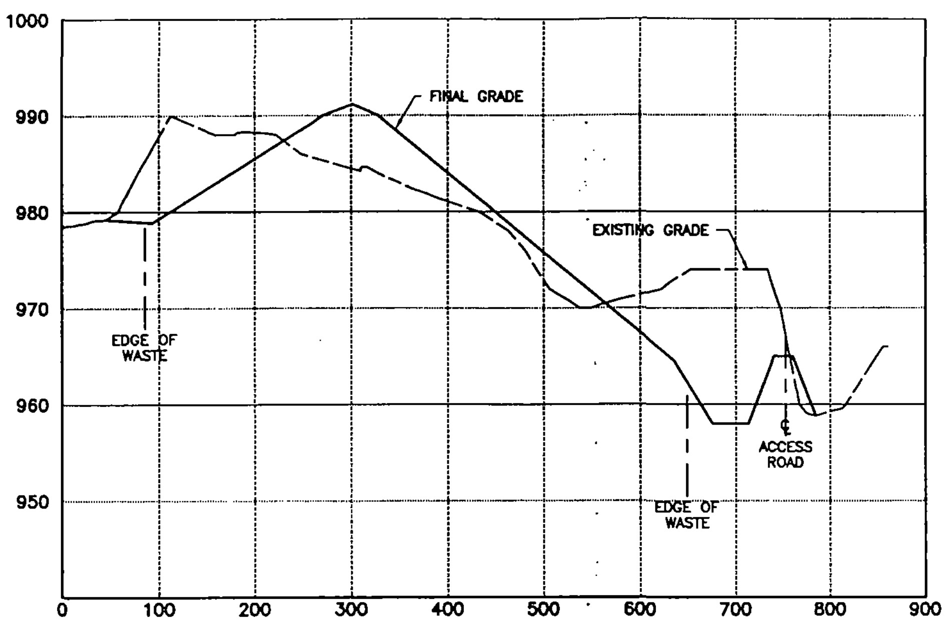
DESIGNED RJ
DRAWN SWH
CHECKED LGH
PEER REVIEWED RMG
PROJECT MANAGER RGG
DATE 1/10/97

Albion–Sheridan Township Landfill — Albion, Michigan

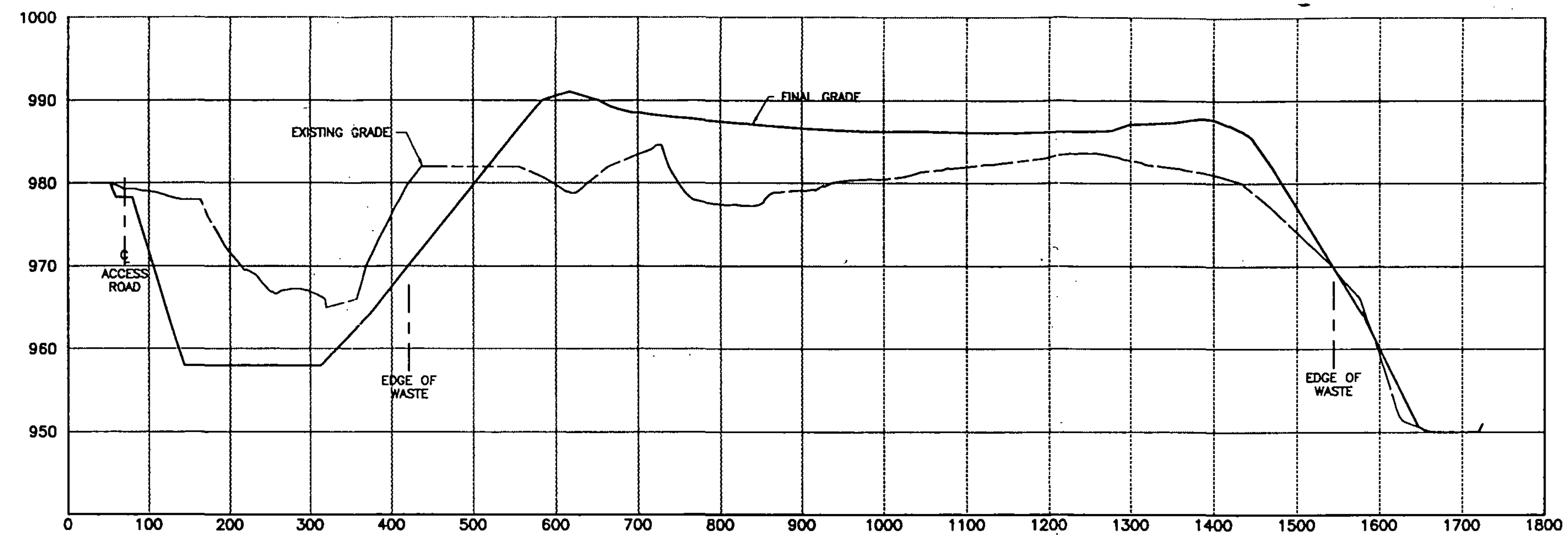
GRADING AND WASTE CONSOLIDATION PLAN

REVISION
PROJECT 6E13045
DRAWING 3
SHEET 3 OF

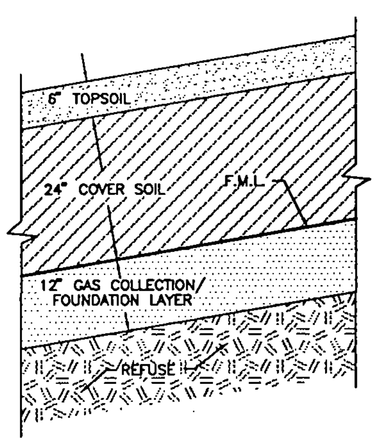
SWH 1/10/97 PROJ. # 6E13045 TASK # LOC. Mpls, Mn PROJ. SEND TO PHONE (612)593-5650



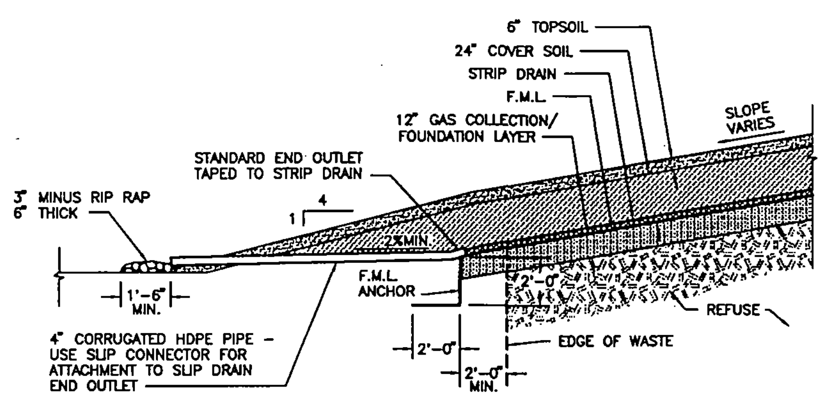
SECTION A 3|4
FINAL GRADING (EAST–WEST)
SCALE:
HORIZONTAL: 1" = 100'-0"
VERTICAL: 1" = 10'-0"



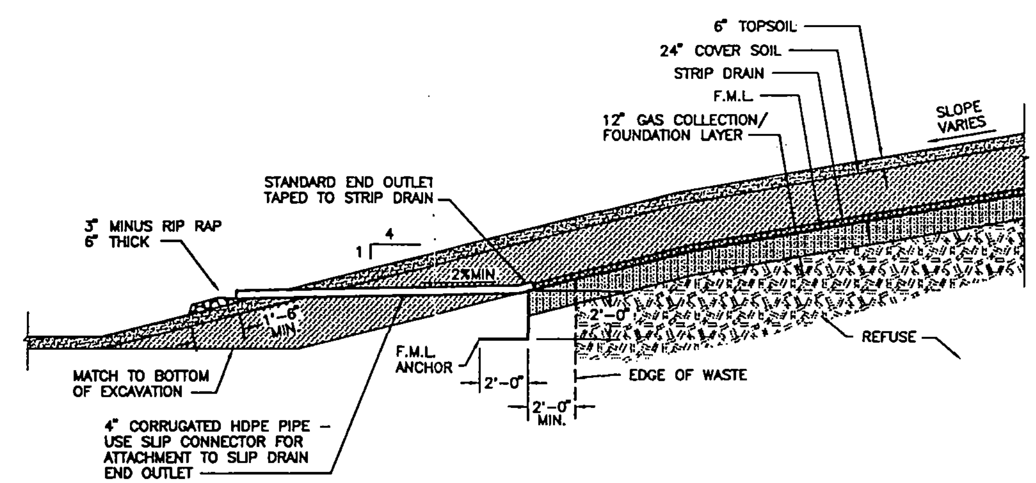
SECTION B 3|4
FINAL GRADING (NORTH–SOUTH)
SCALE:
HORIZONTAL: 1" = 100'-0"
VERTICAL: 1" = 10'-0"



SECTION C 3|4
LANDFILL COVER SYSTEM
N.T.S.



SECTION D 3|4
ANCHOR TRENCH
(WEST AND SOUTH SIDE)



SECTION E 3|4
ANCHOR TRENCH
(NORTH AND EAST SIDE)

NOT FOR CONSTRUCTION

REV	DESCRIPTION OF REVISION	BY	DATE

Woodward-Clyde Consultants
Engineering & sciences applied to the earth & its environment
Park Place West Building, Suite 660
6465 Wayzata Boulevard
Minneapolis, Minnesota 55426

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

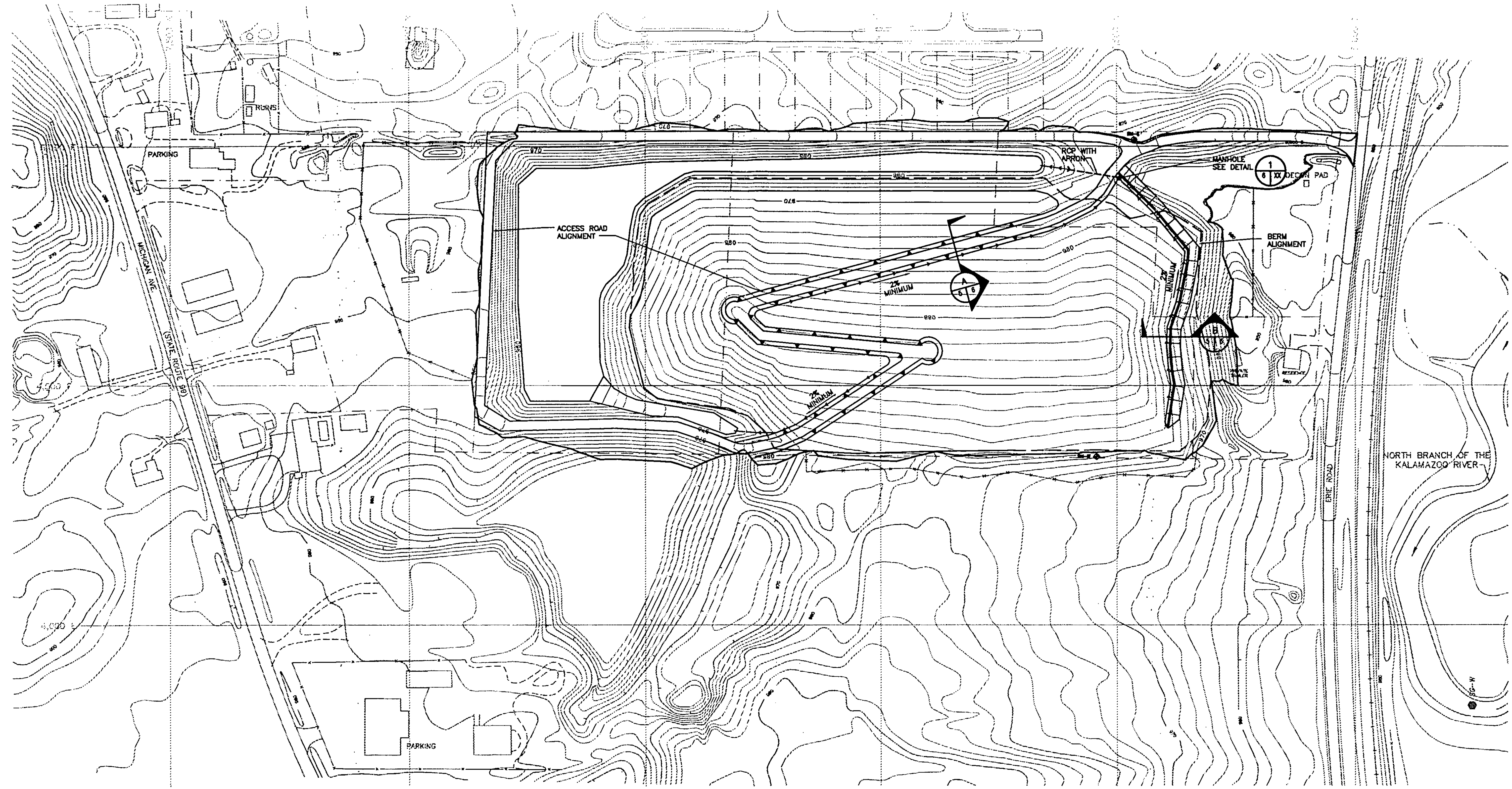
DESIGNED	RJ
DRAWN	SWH
CHECKED	LGH
PEER REVIEWED	RMG
PROJECT MANAGER	RGC
DATE	1/10/97

Albion–Sheridan Township Landfill — Albion, Michigan

COVER SYSTEM
SECTIONS AND DETAILS

REVISION	
PROJECT	63E13045
DRAWING	4
SHEET	4 OF

SWH 1-10-97 PROJ. # 63E13045 LOC. Mpls, Mn SEND TO PHONE (612)593-5650
FILE # 3045-07 SCALE 1:1



PLAN

STORMWATER CONTROL
SCALE: 1" = 100'-0"

100 0 100
SCALE IN FEET

NOT FOR CONSTRUCTION

REV	DESCRIPTION OF REVISION	BY	DATE
△			
△			
△			
△			
△			

Woodward-Clyde Consultants
Engineering & sciences applied to the earth & its environment
Park Place West Building, Suite 660
6465 Wayzata Boulevard
Minneapolis, Minnesota 55426

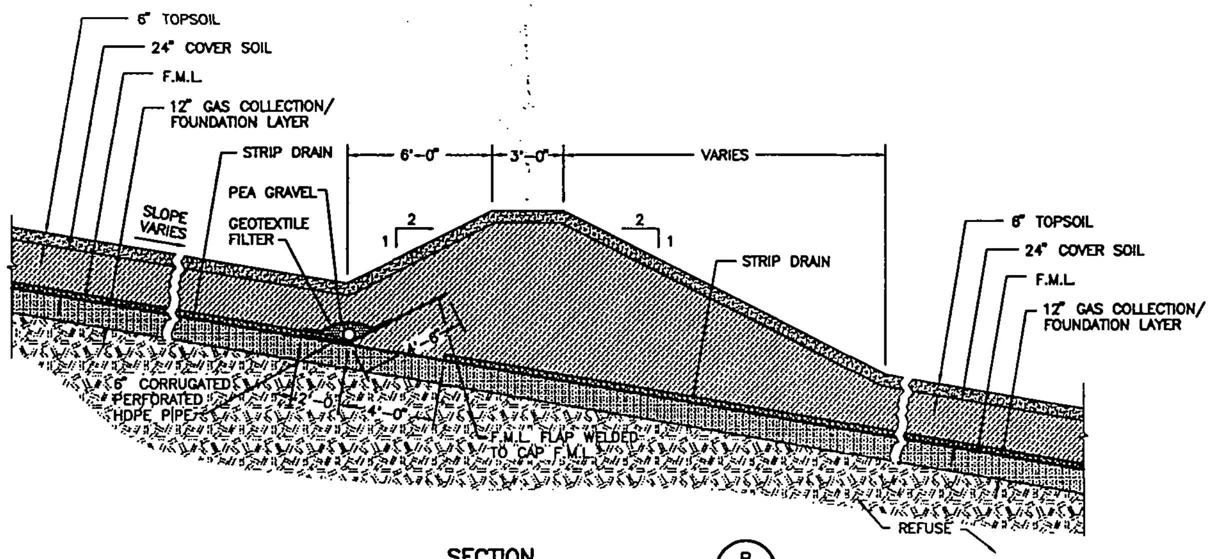
WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED	RJ
DRAWN	SWH
CHECKED	LGH
PEER REVIEWED	RMG
PROJECT MANAGER	RGG
DATE	1/10/97

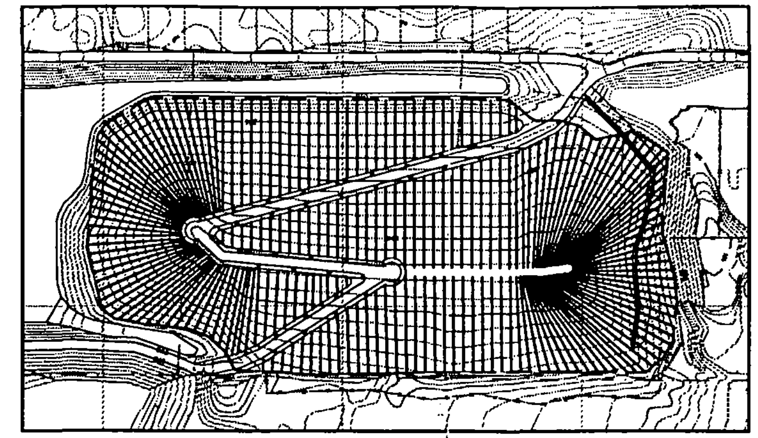
Albion–Sheridan Township Landfill — Albion, Michigan

STORMWATER CONTROL AND ACCESS ROAD LAYOUT PLAN

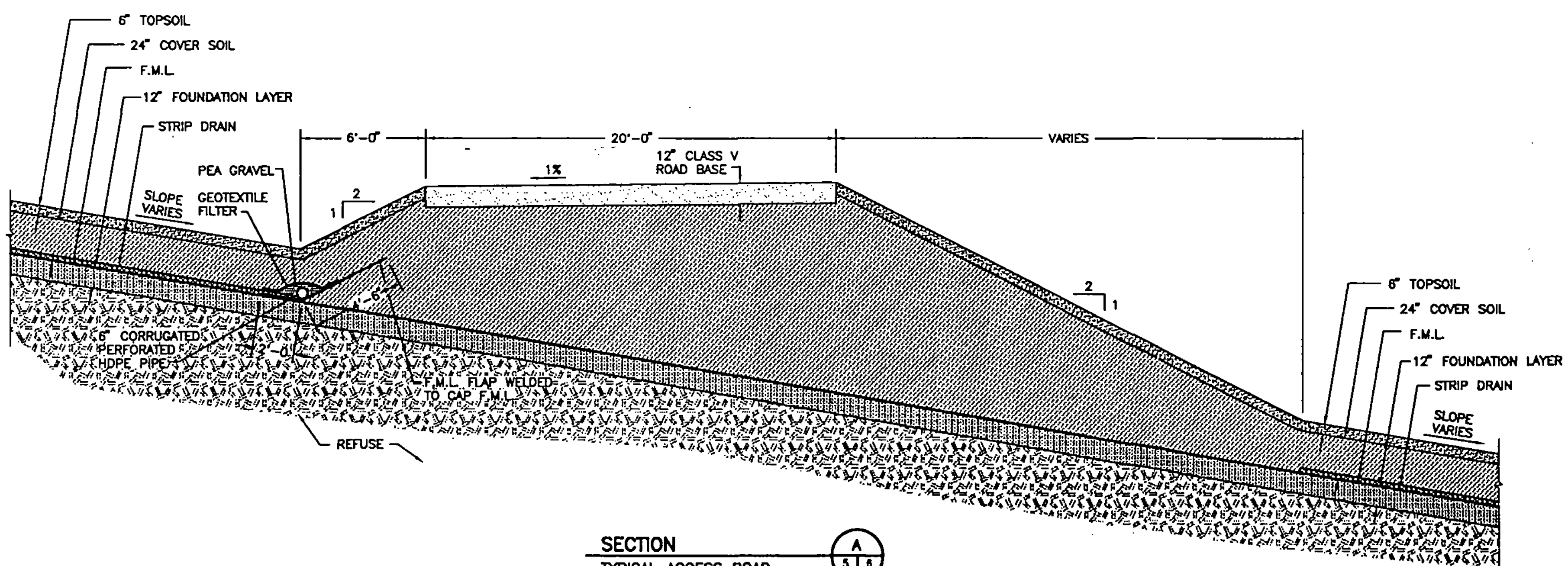
REVISION △
PROJECT 6E13045
DRAWING 5
SHEET 5 OF



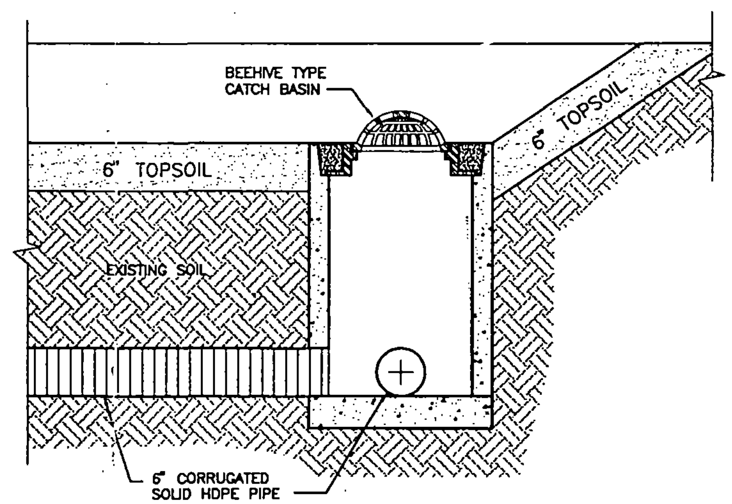
SECTION (B, 5/6)
TYPICAL BERM



PLAN
STRIPDRAIN LOCATIONS
SCALE: 1" = 200'-0"



SECTION (A, 5/6)
TYPICAL ACCESS ROAD
(ON CAP)



DETAIL (1, 5/6)
CATCH BASIN
N.T.S.

NOT FOR CONSTRUCTION

REV	DESCRIPTION OF REVISION	BY	DATE
△			
△			
△			
△			
△			
△			

Woodward-Clyde Consultants
Engineering & sciences applied to the earth & its environment
Park Place West Building, Suite 660
6465 Wayzata Boulevard
Minneapolis, Minnesota 55426

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

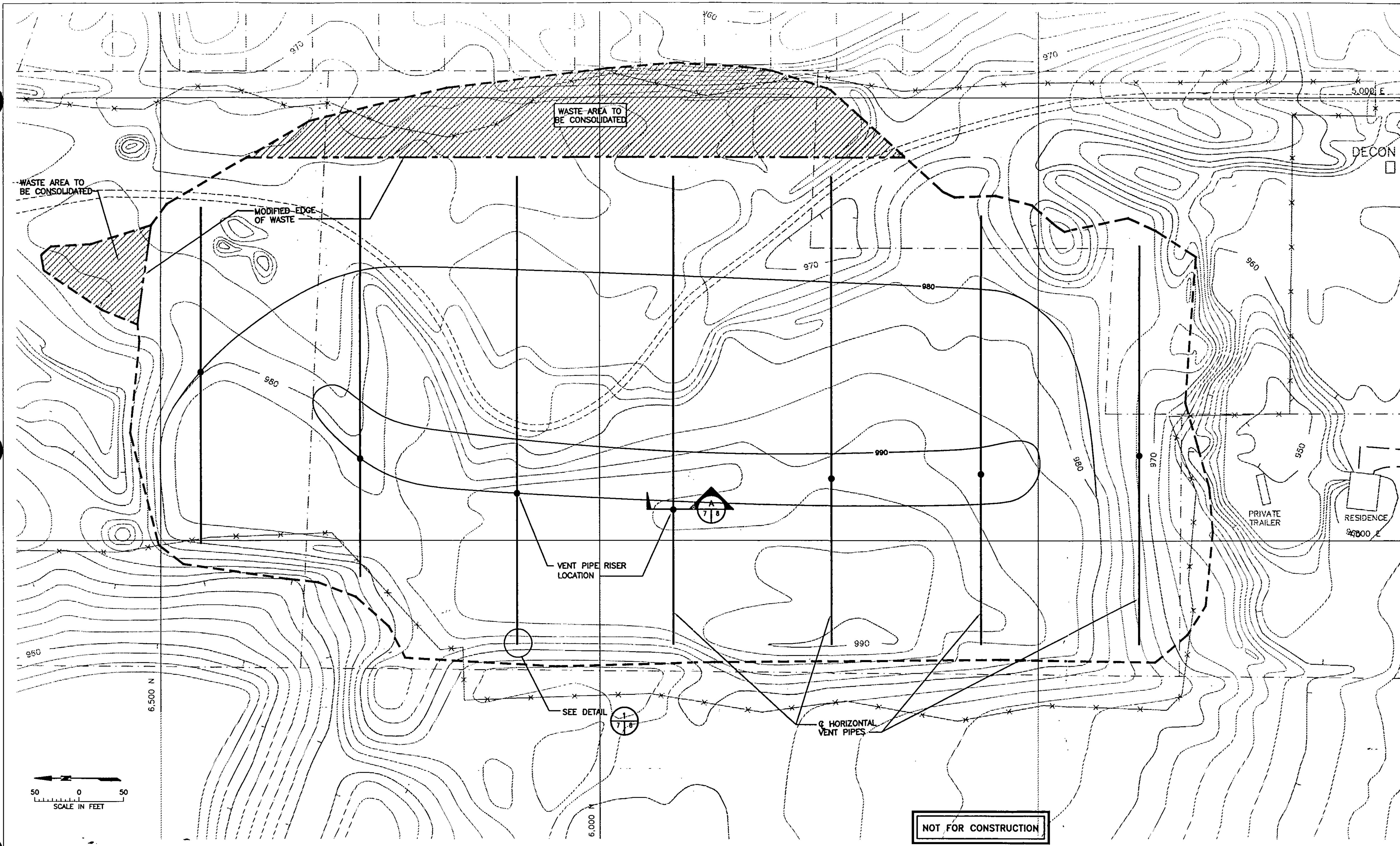
DESIGNED	RJ
DRAWN	SWH
CHECKED	LGH
PEER REVIEWED	RMG
PROJECT MANAGER	RGG
DATE	1/10/97

Albion–Sheridan Township Landfill — Albion, Michigan

STORMWATER CONTROL
SECTIONS AND DETAILS

REVISION △
PROJECT 63E13045
DRAWING 6
SHEET 6 OF

FILE 2045-08 SCALE 1:1 | SVH | PROJ. 63E13045 TASK | LOC. Mpls, Mn PROJ. | SEND TO PHONE (612)593-5650



REV	DESCRIPTION OF REVISION	BY	DATE

Woodward-Clyde Consultants
Engineering & sciences applied to the earth & its environment
Park Place West Building, Suite 660
6465 Wayzata Boulevard
Minneapolis, Minnesota 55426

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

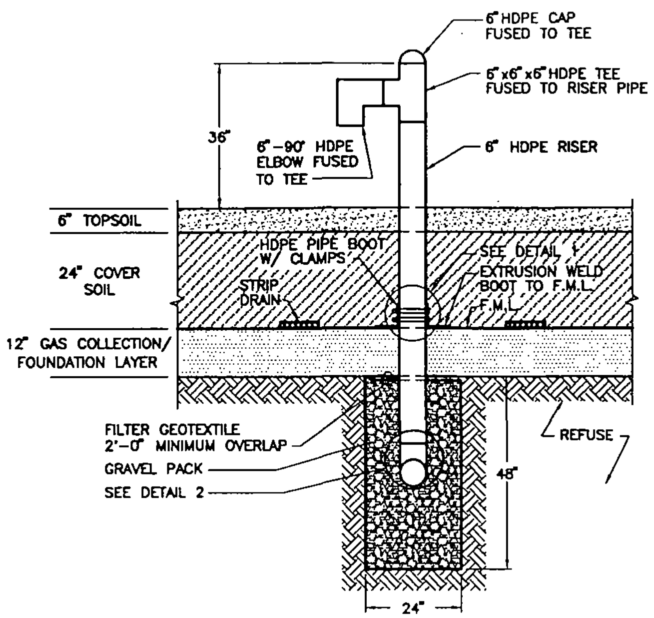
DESIGNED	RJ
DRAWN	SWH
CHECKED	LGH
PEER REVIEWED	RMG
PROJECT MANAGER	RGC
DATE	1/10/97

Albion–Sheridan Township Landfill — Albion, Michigan

PASSIVE LANDFILL GAS CONTROL PLAN

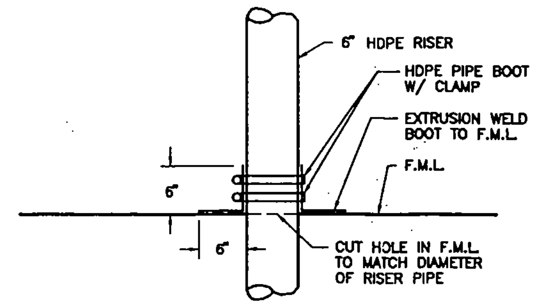
REVISION △
PROJECT 6E13045
DRAWING **7**
SHEET 7 OF

SVH 1/10/96 | PROJ. 6E13045 | TASK | LOC. Mpls, Mn | PROJ. | SEND TO | PHONE (612)593-5650
FILE 2045-05 SCALE 1:1



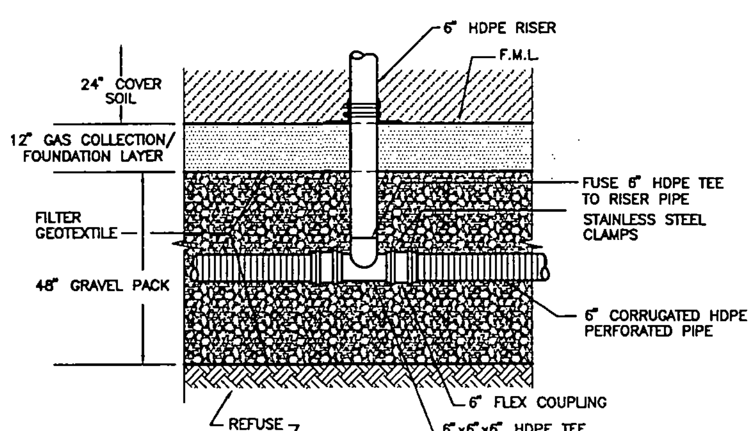
SECTION A (7 | 8)

LANDFILL GAS HORIZONTAL VENT WELL



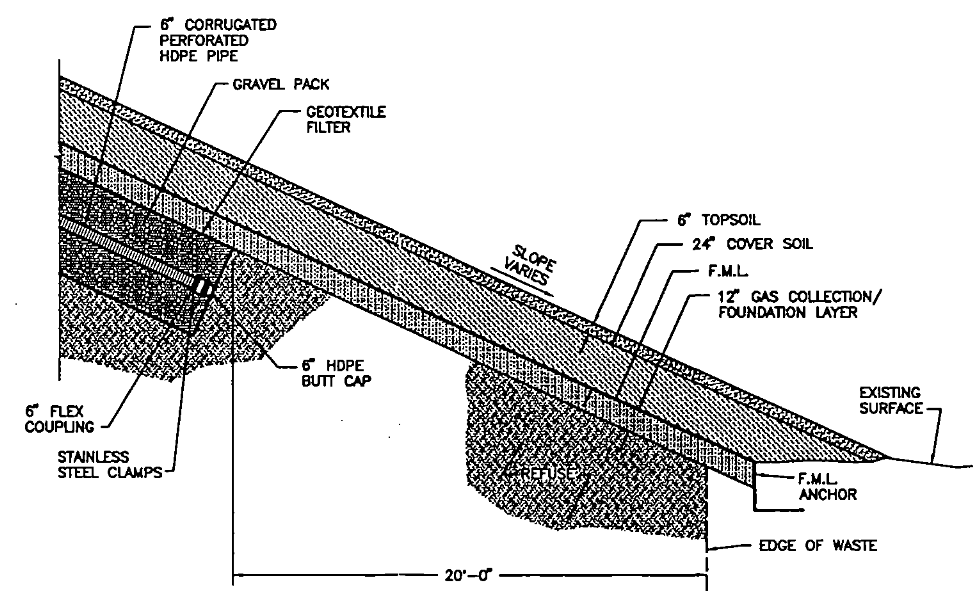
DETAIL 1 (XX | XX)

LANDFILL GAS HORIZONTAL VENT WELL



DETAIL 2 (7 | 8)

LANDFILL GAS HORIZONTAL VENT WELL



DETAIL C (XX | XX)

HORIZONTAL VENT WELL END CONFIGURATION

NOT FOR CONSTRUCTION

REV	DESCRIPTION OF REVISION	BY	DATE
△			
△			
△			
△			
△			
△			

Woodward-Clyde Consultants

Engineering & sciences applied to the earth & its environment

Park Place West Building, Suite 660
6465 Wayzata Boulevard
Minneapolis, Minnesota 55426

WARNING

0 1/2 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED	RJ
DRAWN	SWH
CHECKED	LGH
PEER REVIEWED	RMG
PROJECT MANAGER	RGG
DATE	1/10/97

Albion-Sheridan Township Landfill — Albion, Michigan

PASSIVE LANDFILL GAS SECTIONS AND DETAILS

REVISION △

PROJECT 63E13045

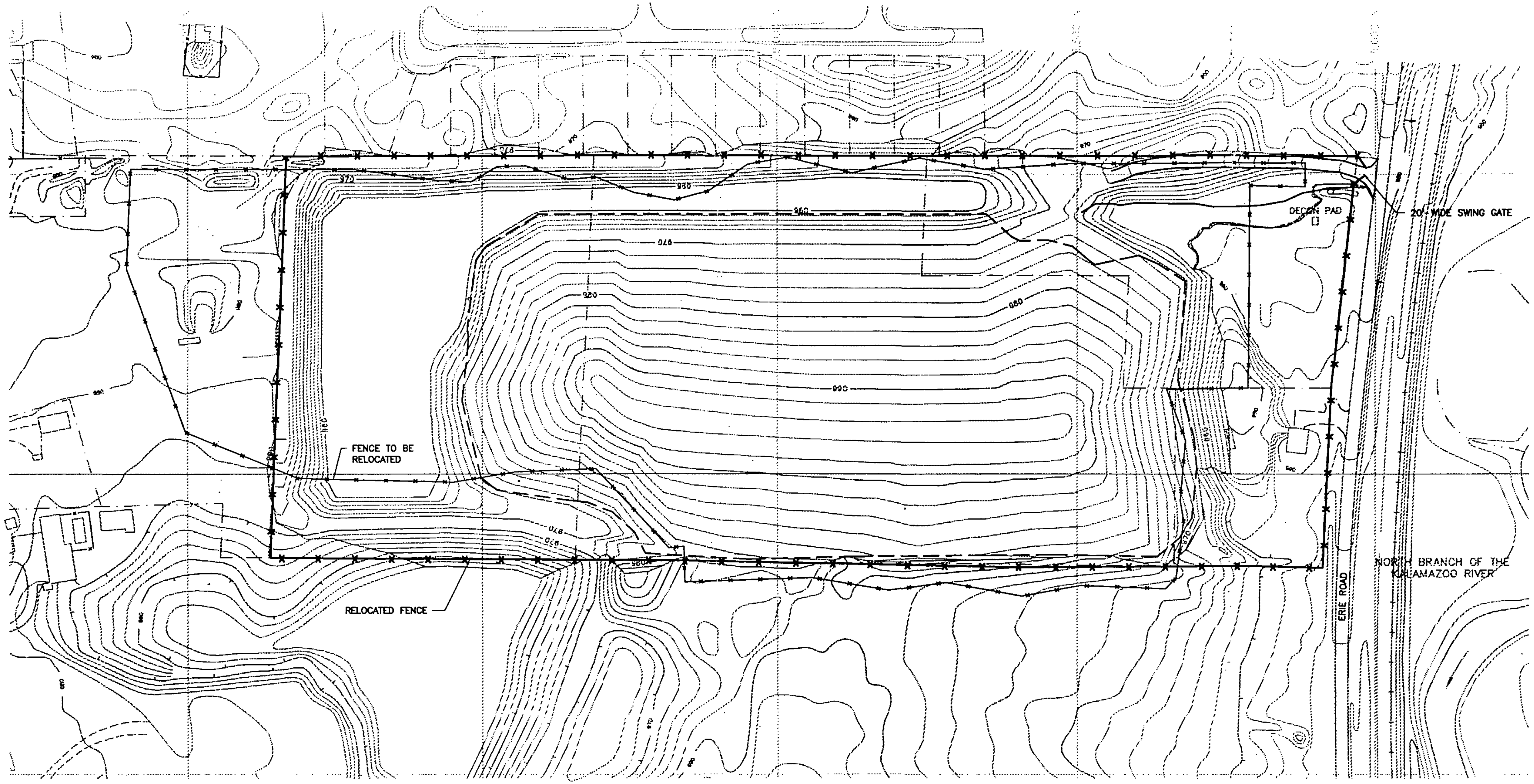
DRAWING 8

SHEET 8 OF

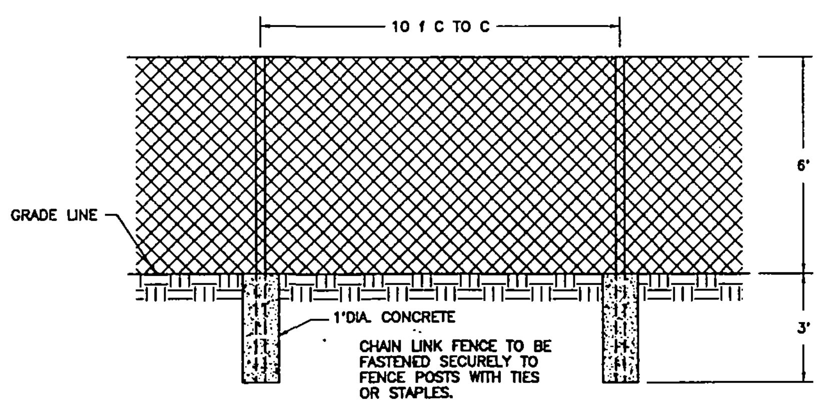
SEND TO | PHONE (612)593-5650

SVH 1/10/97 | PROJ. # 63E13045 | TASK # | LOC. Mpls, Mn | PROJ.

FILE # 3045-02 | SCALE 1:1



PLAN
FENCE RELOCATION
SCALE: 1" = 100'-0"



DETAIL 1/9
CHAIN LINK FENCE
N.T.S.

NOT FOR CONSTRUCTION

REV	DESCRIPTION OF REVISION	BY	DATE
△			
△			
△			
△			
△			
△			

Woodward-Clyde Consultants
Engineering & sciences applied to the earth & its environment
Park Place West Building, Suite 660
6465 Wayzata Boulevard
Minneapolis, Minnesota 55426

WARNING
0 1/2 1
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED RJ
DRAWN SWH
CHECKED LGH
PEER REVIEWED RMG
PROJECT MANAGER RGC
DATE 1/10/97

Albion–Sheridan Township Landfill Albion, Michigan

PERIMETER FENCE
PLAN AND DETAIL

REVISION △
PROJECT 6E13045
DRAWING 9
SHEET 9 OF

FILE # 3045-09 | SCALE 1:100 | DATE 1/10/97 | SWH | PROJ. # 6E13045 | TASK # 210 | LOC. Mpls. Mn | PROJ. ALBION-SHERIDAN | SEND TO | PHONE (612)593-5650

APPENDICES

A

SLOPE STABILITY ANALYSIS

WOODWARD - CLYDE CONSULTANTS

Project Name: ALBION-SHERIDAN TOWNSHIP LANDFILL
Project Number: 6E13045
Calulations by: Robb Johnson
Date: December 11, 1996

Checked By: John Kittelson
Date: December 11, 1996

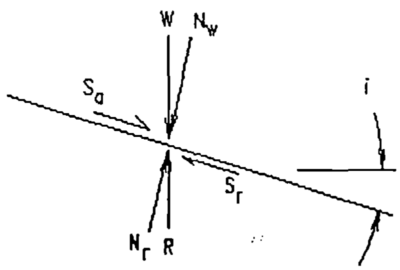
SLOPE STABILITY OF A MULTILAYERED COVER SYSTEM

A mass of soil bounded by a sloping surface is subjected to shearing forces because gravitational forces will tend to pull the upper portion of the mass to more nearly level surface. As stated by Emil, the failure of cover soils with uniform depth is basically a surface raveling type of failure along the interface and can be analized by an infinite slope analysis to determine a safety factor.

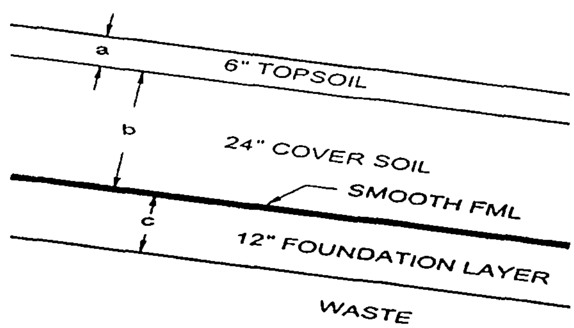
Assumptions for the soil properties were based on project site observations made during the pre-design studies. Soil observed was a silty, medium-grained sand.

Assumptions for a non-textured 40 mil LLDPE liner friction angle were provided by GSE and were based on typical Ottowa Sand/FML direct shear testing data.

To analyze the problem consider the forces acting on the interface of different soil layers:



TYPICAL FINAL COVER SYSTEM



Coefficients are as follows:

$x := 6.66$ Slope ratio, ex. 6.66:1 (15% Slope Grade)

$i := \operatorname{atan}\left(\frac{1}{x}\right)$ $i = 8.5 \cdot \text{deg}$

$\gamma_w := 62.4 \cdot \frac{\text{lb}}{\text{ft}^3}$ Unit weight of water, pcf

$a := 6 \cdot in$	Thickness of topsoil, inches
$b := 24 \cdot in$	Thickness of cover soil, inches
$c := 12 \cdot in$	Thickness of foundation layer, inches
$W_a := 120 \cdot \frac{lb}{ft^3}$	Dry unit weight of topsoil, pcf
$W_{as} := 130 \cdot \frac{lb}{ft^3}$	Saturated unit weight of topsoil, pcf
$C_a := 20 \cdot \frac{lb}{ft^2}$	Cohesion of topsoil, psf
$f_a := 25 \cdot deg$	Friction angle of topsoil, degrees
$\delta_{ab} := 23 \cdot deg$	Interface friction angle between topsoil and cover soil, deg.
$W_b := 120 \cdot \frac{lb}{ft^3}$	Dry unit weight of cover soil, pcf
$W_{bs} := 130 \cdot \frac{lb}{ft^3}$	Saturated unit weight of cover soil, pcf
$C_b := 5 \cdot \frac{lb}{ft^2}$	Cohesion of cover soil, psf
$f_b := 23 \cdot deg$	Friction angle of cover soil, degrees
$\delta_{bfml} := 19 \cdot deg$	Interface friction angle between cover soil and FML, deg.
$\delta_{fmlc} := 19 \cdot deg$	Interface friction angle between FML and foundation layer, deg.
$W_c := 120 \cdot \frac{lb}{ft^3}$	Dry unit weight of foundation layer, pcf
$W_{cs} := 130 \cdot \frac{lb}{ft^3}$	Saturated unit weight of foundation layer, pcf
$C_c := 0 \cdot \frac{lb}{ft^2}$	Cohesion of foundation layer, psf
$f_c := 23 \cdot deg$	Friction angle of foundation layer, degrees
$\delta_{cw} := 23 \cdot deg$	Interface friction angle between foundation layer and waste, deg.

Assume the worst case. The topsoil and cover soil are saturated above the relatively imperivous FML and there is seepage parallel to the slope. It is further assumed that that while the FML and foundation layer are saturated, no seepage takes place in these two layers due to a more static water level.

$h := (a + b)\cdot\cos(i)^2$ Pore water pressure head

Each interface is analyzed:

Topsoil - Cover Soil

$h_a := h - b$ Pore pressure head at depth a

$$W := W_a\cdot(a - h_a) + W_{as}\cdot h_a$$

$$FS_{ab} := \frac{\tan(\delta_{ab})}{\tan(i)}\cdot\left[\left(1 - \frac{h_a\cdot\gamma_w}{W}\right)\cdot\sec(i)^2\right]$$

$FS_{ab} = 1.65$ **Factor of safety of the topsoil - cover soil interface**

Cover Soil - FML

$h_b := h$ Pore pressure head at depth a + b

$$W := \left[W_a\cdot(a + b - h_b)\right] + (W_{bs}\cdot b) + \left[W_{as}\cdot(h_b - b)\right]$$

$$FS_{bfml} := \frac{\tan(\delta_{bfml})}{\tan(i)}\cdot\left[\left(1 - \frac{\gamma_w\cdot h_b}{W}\right)\cdot\sec(i)^2\right]$$

$FS_{bfml} = 1.24$ **Factor of safety of the cover soil - FML interface**

FML - Foundation Layer

Assume the water level in the saturated foundation layer is static and does not contribute to any seepage forces.

$$FS_{fmlc} := \frac{\tan(\delta_{fmlc})}{\tan(i)}$$

$FS_{fmlc} = 2.29$ Factor of safety of the FML - Foundation layer interface

Foundation Layer - Waste

Assume the water level in the saturated foundation layer and waste is static and does not contribute to any seepage forces.

$$FS_{cfml} := \frac{\tan\left(\delta_{cw}\right)}{\tan(i)}$$

$FS_{cfml} = 2.83$ **Factor of safety of the Foundation Layer - Waste interface**

If FS is greater than one in all cases then slope should be stable against slumping failure, if FS is less than one then the liner system should be redesigned.

References: Edil, T.B., "Slope Stability Issues in Waste Disposal," from presentation presented at Waste Geotechnics course, University of Wisconsin, January, 1991.

Lambe, T.W. and R.V. Whitman, "Soil Mechanics," John Wiley and Sons, New York, New York, 1969.

Koerner, Robert M.,"Designing With Geosynthetics," 3rd Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1994, 1990, 1986.

WOODWARD - CLYDE CONSULTANTS

Project Name: ALBION-SHERIDAN TOWNSHIP LANDFILL
Project Number: 6E13045
Calulations by: Robb Johnson
Date: December 12, 1996

Checked By: John Kittelson
Date: December 12, 1996

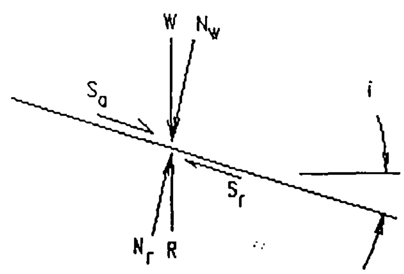
SLOPE STABILITY OF A MULTILAYERED COVER SYSTEM

A mass of soil bounded by a sloping surface is subjected to shearing forces because gravitational forces will tend to pull the upper portion of the mass to more nearly level surface. As stated by Emil, the failure of cover soils with uniform depth is basically a surface raveling type of failure along the interface and can be analized by an infinite slope analysis to determine a safety factor.

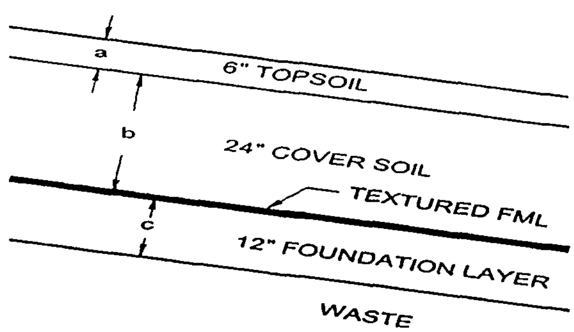
Assumptions for the soil properties were based on project site observations made during the pre-design studies. Soil observed was a silty, medium-grained sand.

Assumptions for a textured 40 mil LLDPE liner friction angle were provided by GSE and were based on typical Ottowa Sand/FML direct shear testing data.

To analyze the problem consider the forces acting on the interface of different soil layers:



TYPICAL FINAL COVER SYSTEM



Coefficients are as follows:

$x := 4.0$ Slope ratio, ex. 4:1

$i := \operatorname{atan}\left(\frac{1}{x}\right)$ $i = 14 \cdot \mathrm{deg}$

$\gamma_w := 62.4 \cdot \frac{\mathrm{lb}}{\mathrm{ft}^3}$ Unit weight of water, pcf

$a := 6 \cdot in$	Thickness of topsoil, inches
$b := 24 \cdot in$	Thickness of cover soil, inches
$c := 12 \cdot in$	Thickness of foundation layer, inches
$W_a := 120 \cdot \frac{lb}{ft^3}$	Dry unit weight of topsoil, pcf
$W_{as} := 130 \cdot \frac{lb}{ft^3}$	Saturated unit weight of topsoil, pcf
$C_a := 20 \cdot \frac{lb}{ft^2}$	Cohesion of topsoil, psf
$f_a := 25 \cdot deg$	Friction angle of topsoil, degrees
$\delta_{ab} := 23 \cdot deg$	Interface friction angle between topsoil and cover soil, deg.
$W_b := 120 \cdot \frac{lb}{ft^3}$	Dry unit weight of cover soil, pcf
$W_{bs} := 130 \cdot \frac{lb}{ft^3}$	Saturated unit weight of cover soil, pcf
$C_b := 5 \cdot \frac{lb}{ft^2}$	Cohesion of cover soil, psf
$f_b := 23 \cdot deg$	Friction angle of cover soil, degrees
$\delta_{bfml} := 30 \cdot deg$	Interface friction angle between cover soil and FML, deg.
$\delta_{fmlc} := 30 \cdot deg$	Interface friction angle between FML and foundation layer, deg.
$W_c := 120 \cdot \frac{lb}{ft^3}$	Dry unit weight of foundation layer, pcf
$W_{cs} := 130 \cdot \frac{lb}{ft^3}$	Saturated unit weight of foundation layer, pcf
$C_c := 0 \cdot \frac{lb}{ft^2}$	Cohesion of foundation layer, psf
$f_c := 23 \cdot deg$	Friction angle of foundation layer, degrees
$\delta_{cw} := 23 \cdot deg$	Interface friction angle between foundation layer and waste, deg.

Assume the worst case. The topsoil and cover soil are saturated above the relatively imperivous FML and there is seepage parallel to the slope. It is further assumed that that while the FML and foundation layer are saturated, no seepage takes place in these two layers due to a more static water level.

$h := (a + b)\cdot\cos(i)^2$ Pore water pressure head

Each interface is analyzed:

Topsoil - Cover Soil

$h_a := h - b$ Pore pressure head at depth a

$$W := W_a\cdot\left(a - h_a\right) + W_{as}\cdot h_a$$

$$FS_{ab} := \frac{\tan\left(\delta_{ab}\right)}{\tan(i)}\cdot\left[\left(1 - \frac{h_a\cdot\gamma_w}{W}\right)\cdot\sec(i)^2\right]$$

$FS_{ab} = 1.18$ **Factor of safety of the topsoil - cover soil interface**

Cover Soil - FML

$h_b := h$ Pore pressure head at depth a + b

$$W := \left[W_a\cdot\left(a + b - h_b\right)\right] + \left(W_{bs}\cdot b\right) + \left[W_{as}\cdot\left(h_b - b\right)\right]$$

$$FS_{bfml} := \frac{\tan\left(\delta_{bfml}\right)}{\tan(i)}\cdot\left[\left(1 - \frac{\gamma_w\cdot h_b}{W}\right)\cdot\sec(i)^2\right]$$

$FS_{bfml} = 1.34$ **Factor of safety of the cover soil - FML interface**

FML - Foundation Layer

Assume the water level in the saturated foundation layer is static and does not contribute to any seepage forces.

$$FS_{fmlc} := \frac{\tan\left(\delta_{fmlc}\right)}{\tan(i)}$$

$FS_{fmlc} = 2.31$ Factor of safety of the FML - Foundation layer interface

Foundation Layer - Waste

Assume the water level in the saturated foundation layer and waste is static and does not contribute to any seepage forces.

$$FS_{cfml} := \frac{\tan(\delta_{cw})}{\tan(i)}$$

$FS_{cfml} = 1.7$ **Factor of safety of the Foundation Layer - Waste interface**

If FS is greater than one in all cases then slope should be stable against slumping failure, if FS is less than one then the liner system should be redesigned.

References: Edil, T.B., "Slope Stability Issues in Waste Disposal," from presentation presented at Waste Geotechnics course, University of Wisconsin, January, 1991.

Lambe, T.W. and R.V. Whitman, "Soil Mechanics," John Wiley and Sons, New York, New York, 1969.

Koerner, Robert M.,"Designing With Geosynthetics," 3rd Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1994, 1990, 1986.

H.E.L.P. MODEL

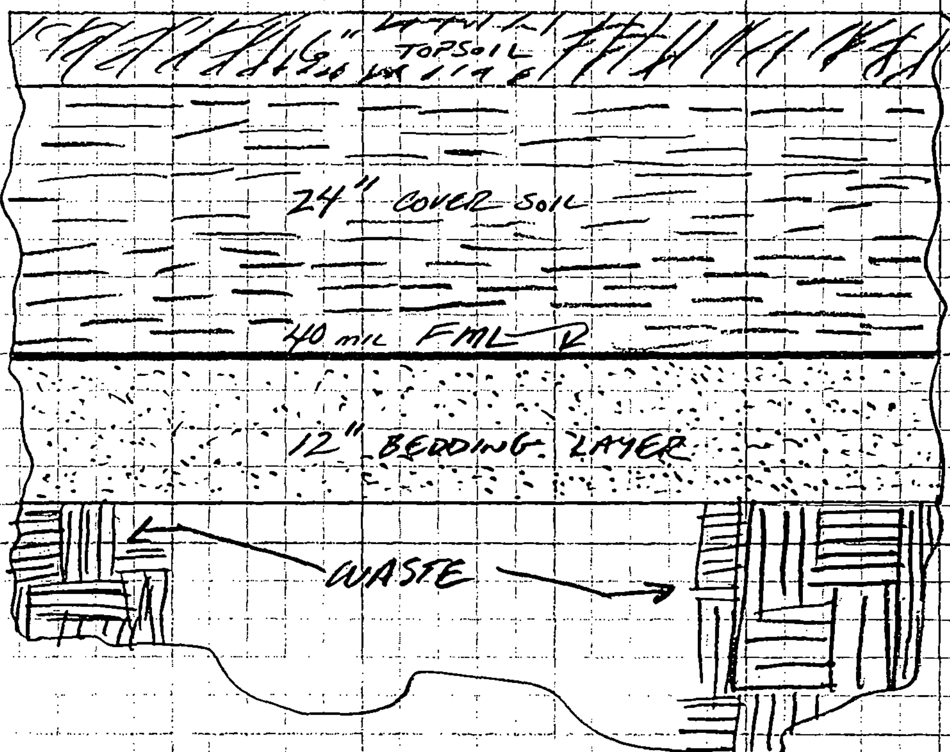
Subject ASTL - H.E.L.P. MODEL (5 YEAR) Project No. 6E13045

By RJ Checked By Task No.

File No.

Date 12-9-96 Date Sheet 1 of 2

TYPICAL COVER SECTION USED:



SOIL TYPES (GENERAL):

TOPSOIL : SM (USCS CLASSIFICATION)

COVER SOIL: SM (USCS CLASSIFICATION)

BEDDING LAYER: SM (USCS CLASSIFICATION)

HYDRAULIC CONDUCTIVITIES:

TOP SOIL: 7.2×10^{-4} cm/SEC

COVER SOIL: 5.2×10^{-4} cm/SEC

BEDDING LAYER: 5.2×10^{-4} cm/SEC

Subject ASTL - H.E.L.P. MODEL

Project No. 6E13045

By RJ

Checked By

Task No.

File No.

Date 12-9-96

Date

F.M.L. INPUT PARAMETERS USED:

F.M.L. PINHOLE DENSITY: 0.75 HOLES/ACRE
(RECOMMENDED RANGE = 0.5 TO 1.0)

F.M.L. INSTALLATION DEFECTS: 1.00 HOLES/ACRE
(RECOMMENDED RANGE = 1.00 - 4.00)

F.M.L. PLACEMENT QUALITY: GOOD

1/7

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**          HELP MODEL VERSION 3.03   (31 DECEMBER 1994)                    **
**             DEVELOPED BY ENVIRONMENTAL LABORATORY                        **
**               USAE WATERWAYS EXPERIMENT STATION                          **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3\ASTL.D4
TEMPERATURE DATA FILE:        C:\HELP3\ASTL.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\ASTL.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\ASTL.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\ASTL.D10
OUTPUT DATA FILE:             C:\HELP3\ASTL.OUT


TIME:  16:12      DATE:  12/ 9/1996


******************************************************************************

     TITLE:  ALBION-SHERIDAN TOWNSHIP LANDFILL

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   6
           THICKNESS                    =        6.00   INCHES
           POROSITY                     =        0.4530 VOL/VOL
           FIELD CAPACITY               =        0.1900 VOL/VOL
           WILTING POINT                =        0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT   =        0.3457 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =    0.720000011000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2636	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC
SLOPE	=	0.00	PERCENT
DRAINAGE LENGTH	=	0.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC
FML PINHOLE DENSITY	=	0.75	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 4.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	70.50	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.181	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.340	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.966	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.401	INCHES
TOTAL INITIAL WATER	=	8.401	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

3/7

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
E. LANSING MICHIGAN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	123
END OF GROWING SEASON (JULIAN DATE)	=	283
AVERAGE ANNUAL WIND SPEED	=	10.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	69.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	75.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	80.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DETROIT MICHIGAN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.86	1.69	2.54	3.15	2.77	3.43
3.10	3.21	2.25	2.12	2.33	2.52

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR E. LANSING MICHIGAN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.60	23.30	33.00	46.30	57.20	66.80
70.80	69.20	61.70	50.70	38.50	27.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR E. LANSING MICHIGAN

STATION LATITUDE = 42.60 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						

4/7

TOTALS	1.78	1.64	2.39	4.10	3.71	4.04
	2.70	3.30	1.70	0.95	2.88	3.17
STD. DEVIATIONS	0.64	0.65	1.28	1.20	1.61	1.04
	1.31	1.70	0.93	0.37	1.23	0.94

RUNOFF

TOTALS	0.662	0.772	1.362	1.616	0.005	0.000
	0.000	0.000	0.000	0.000	0.000	0.719
STD. DEVIATIONS	0.849	0.795	1.418	0.983	0.011	0.000
	0.000	0.000	0.000	0.000	0.000	0.944

EVAPOTRANSPIRATION

TOTALS	0.525	0.649	1.192	3.005	3.427	4.965
	2.912	2.538	1.920	0.964	0.621	0.411
STD. DEVIATIONS	0.085	0.172	0.281	0.783	1.138	0.586
	1.227	0.678	0.590	0.457	0.096	0.037

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	0.0000	0.0000	0.0000	1.3448	1.1422	0.5694
	0.0019	0.3478	0.0874	0.0002	0.0369	0.5922
STD. DEVIATIONS	0.0000	0.0000	0.0000	1.2251	0.5822	0.3325
	0.0031	0.7754	0.1702	0.0004	0.0823	0.7055

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 3

AVERAGES	0.0000	0.0000	0.0000	0.0196	0.0170	0.0084
	0.0000	0.0056	0.0013	0.0000	0.0001	0.0092
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0198	0.0091	0.0056
	0.0001	0.0126	0.0025	0.0000	0.0003	0.0116

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

5/7

	INCHES		CU. FEET	PERCENT
PRECIPITATION	32.34	(3.821)	117387.0	100.00
RUNOFF	5.135	(1.7538)	18640.63	15.880
EVAPOTRANSPIRATION	23.130	(1.8751)	83961.09	71.525
LATERAL DRAINAGE COLLECTED FROM LAYER 2	4.12285	(2.61859)	14965.949	12.74924
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00000	(0.00000)	0.000	0.00000
AVERAGE HEAD ACROSS TOP OF LAYER 3	0.005	(0.003)		
CHANGE IN WATER STORAGE	-0.050	(0.4140)	-180.72	-0.154

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.56	9292.800
RUNOFF	2.349	8526.0117
DRAINAGE COLLECTED FROM LAYER 2	1.69496	6152.68896
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000000	0.00000
AVERAGE HEAD ACROSS LAYER 3	0.981	
SNOW WATER	3.19	11574.1309

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3764
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0814

****

****

FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	1.5724	0.2621
2	6.5792	0.2741
3	0.0000	0.0000
SNOW WATER	0.000	

****
****

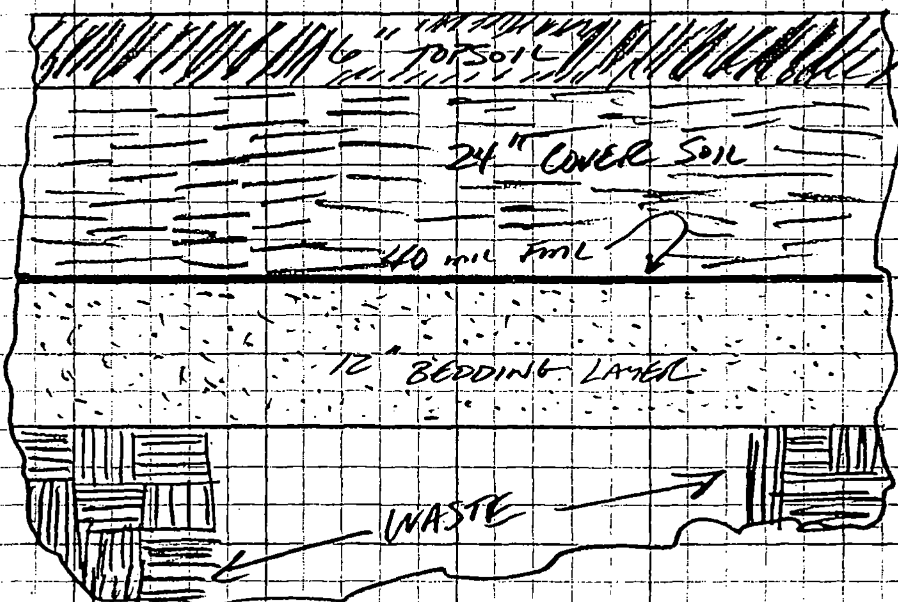
Subject ASTL - HELP MODEL (25 YEAR) Project No. 6E13045

By RJ Checked By Task No. 210

File No.

Date 12-12-96 Date Sheet 1 of 2

TYPICAL COVER SECTION USED:



SOIL TYPES (GENERAL):

TOPSOIL : SM (USCS CLASSIFICATION)

COVER SOIL : SM (USCS CLASSIFICATION)

BEDDING LAYER : SM (USCS CLASSIFICATION)

HYDRAULIC CONDUCTIVITIES:

TOPSOIL : 7.2×10^{-4} cm/SEC

COVER SOIL : 5.2×10^{-4} cm/SEC

BEDDING LAYER : 5.2×10^{-4} cm/SEC

Subject ASTL - HELP MODEL (25 YEAR)

Project No. GE-13045

By RJ

Checked By

Task No. 210

File No.

Date 12-12-96

Date

Sheet 2 of 2

FML INPUT PARAMETERS USED:

FML PINHOLE DENSITY: 1.00 HOLES/ACRE

(RECOMMENDED RANGE = 0.5 - 1.0)

FML INSTALLATION DEFECTS: 4.00 HOLES/ACRE

(RECOMMENDED RANGE = 1.00 - 4.00)

FML PLACEMENT QUALITY: GOOD

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.03  (31 DECEMBER 1994)                **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3\ASTL2.D4
TEMPERATURE DATA FILE:        C:\HELP3\ASTL2.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\ASTL2.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\ASTL2.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\ASTL2.D10
OUTPUT DATA FILE:             C:\HELP3\ASTL2.OUT


TIME:  15:56     DATE:  12/12/1996


******************************************************************************

     TITLE:  ALBION-SHERIDAN TOWNSHIP LANDFILL

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER   6
           THICKNESS                     =        6.00    INCHES
           POROSITY                      =        0.4530 VOL/VOL
           FIELD CAPACITY                =        0.1900 VOL/VOL
           WILTING POINT                 =        0.0850 VOL/VOL
           INITIAL SOIL WATER CONTENT    =        0.3412 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =    0.720000011000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2588	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC
SLOPE	=	0.00	PERCENT
DRAINAGE LENGTH	=	0.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	12.00	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 4.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	70.50	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.037	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.340	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.966	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.257	INCHES
TOTAL INITIAL WATER	=	8.257	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
E. LANSING MICHIGAN

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	123
END OF GROWING SEASON (JULIAN DATE)	=	283
AVERAGE ANNUAL WIND SPEED	=	10.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	69.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	75.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	80.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DETROIT MICHIGAN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.86	1.69	2.54	3.15	2.77	3.43
3.10	3.21	2.25	2.12	2.33	2.52

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR E. LANSING MICHIGAN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.60	23.30	33.00	46.30	57.20	66.80
70.80	69.20	61.70	50.70	38.50	27.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR E. LANSING MICHIGAN

STATION LATITUDE = 42.60 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 25

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						

TOTALS	1.81	1.73	2.32	3.26	3.07	3.40
	3.00	2.93	2.55	1.65	2.46	2.78
STD. DEVIATIONS	0.69	0.82	1.02	1.22	1.17	1.47
	1.23	1.73	1.36	1.11	1.06	1.06

RUNOFF

TOTALS	0.664	0.945	1.161	0.651	0.001	0.000
	0.001	0.002	0.000	0.000	0.005	0.289
STD. DEVIATIONS	0.824	0.840	0.926	0.859	0.007	0.002
	0.004	0.009	0.000	0.000	0.024	0.505

EVAPOTRANSPIRATION

TOTALS	0.486	0.531	1.512	2.914	3.186	4.178
	3.119	2.307	2.340	1.262	0.714	0.433
STD. DEVIATIONS	0.097	0.155	0.330	0.545	1.026	1.110
	1.130	0.790	0.768	0.452	0.147	0.082

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	0.0148	0.0000	0.2346	1.3028	0.8204	0.4395
	0.0574	0.2050	0.1293	0.0709	0.3797	0.5502
STD. DEVIATIONS	0.0738	0.0000	0.5547	0.8543	0.4909	0.3645
	0.2497	0.5330	0.3135	0.1948	0.6404	0.7177

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 3

AVERAGES	0.0002	0.0000	0.0031	0.0212	0.0111	0.0065
	0.0008	0.0034	0.0019	0.0013	0.0057	0.0083
STD. DEVIATIONS	0.0011	0.0000	0.0083	0.0154	0.0058	0.0055
	0.0034	0.0090	0.0047	0.0043	0.0101	0.0109

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

	INCHES		CU. FEET	PERCENT
PRECIPITATION	30.97	(3.587)	112415.3	100.00
RUNOFF	3.720	(1.6963)	13504.85	12.013
EVAPOTRANSPIRATION	22.981	(1.9178)	83420.59	74.208
LATERAL DRAINAGE COLLECTED FROM LAYER 2	4.20448	(1.83069)	15262.253	13.57667
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00000	(0.00000)	0.000	0.00000
AVERAGE HEAD ACROSS TOP OF LAYER 3	0.005	(0.002)		
CHANGE IN WATER STORAGE	0.063	(1.4297)	227.60	0.202

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

	(INCHES)	(CU. FT.)
PRECIPITATION	2.92	10599.601
RUNOFF	2.771	10059.9111
DRAINAGE COLLECTED FROM LAYER 2	1.57001	5699.14062
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000000	0.00000
AVERAGE HEAD ACROSS LAYER 3	0.937	
SNOW WATER	4.12	14965.1523

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4063
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0814

****

****

FINAL WATER STORAGE AT END OF YEAR 25

LAYER	(INCHES)	(VOL/VOL)
1	1.2322	0.2054
2	5.5294	0.2304
3	0.0000	0.0000
SNOW WATER	0.000	

****
****

ANCHOR TRENCH AND RUNOUT LENGTH ANALYSIS

WOODWARD-CLYDE CONSULTANTS

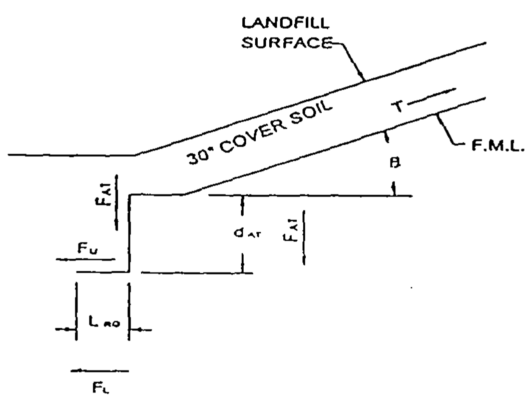
Project Name: ALBION-SHERIDAN TOWNSHIP LANDFILL
Project Number: 6E13045
Calculations by: Robb Johnson
Date: December 18, 1996

Checked by: John Kittelson
Date: December 18, 1996

ANCHOR TRENCH DEPTH AND RUNOUT LENGTH DESIGN

Geomembrane covered landfill caps and cells often require the use of an anchor trench to keep the geomembrane from becoming mobile after installation. Equations developed by Koerner (1990) were used to calculate depth of the anchor trench and runout length required.

ANCHOR TRENCH CONFIGURATION



Coefficients as follows:

$\sigma_{yield} := 5000 \cdot \frac{lb}{in^2}$ the geomembrane stress at break

$FS := 4.0$ the geomembrane factor of safety

$\sigma_{allow} := \frac{\sigma_{yield}}{FS}$ the allowable geomembrane stress

$\sigma_{allow} = 1250 \cdot \frac{lb}{in^2}$

$mil := \frac{1}{1000} \cdot in$

$t := 40 \cdot mil$ the geomembrane thickness

$T_{allow} := \sigma_{allow} \cdot t$	the maximum allowable force
$F_U := 0 \cdot \frac{lb}{in}$	the friction force above the geomembrane (assumed to be negligible, since the cover soil will probably move along with the liner as it deforms)
$d_{cs} := 24 \cdot in$	the depth of the cover soil
$\gamma_{cs} := 125 \cdot \frac{lb}{ft^3}$	the unit weight of the cover soil
$q := d_{cs} \cdot \gamma_{cs}$	the surcharge pressure
$\delta := 30 \cdot deg$	the friction angle between the geomembrane and the soil
$L_{RO} := 2.0 \cdot ft$	the length of runout
$F_L := q \cdot \tan(\delta) \cdot L_{RO}$	the friction force below the geomembrane
$\gamma_{bs} := 125 \cdot \frac{lb}{ft^3}$	the unit weight of backfill soil
$H_{ave} := 2.0 \cdot ft$	the average depth of the anchor trench
$z := 2$	the resisting force acts on both sides of the anchor trench geomembrane
$\phi := 25 \cdot deg$	the angle of shearing resistance of the backfill soil
$K_O := 1 - \sin(\phi)$	
$a := z \cdot K_O \cdot H_{ave} \cdot \gamma_{bs} \cdot \tan(\delta)$	the lateral stress ratio at rest

$$d_t := \frac{T_{allow} - F_U - F_L}{a}$$

$d_t = 1.9 \cdot ft$ **Depth of Anchor Trench**

*The depth of the anchor trench should be no more than dt, this will allow for failure of the anchor trench by pullout before tearing failure of the geomembrane.

References:

Bagchi, A., 1990, "Design, Construction, and Monitoring of Sanitary Landfill," John Wiley and Sons.

Koerner, R.M., 1990, "Designing with Geosynthetics, 2nd Ed.," Prentice Hall, Englewood, New Jersey.

Lambe, T.W. and R.V. Whitman, 1969, "Soil Mechanics," John Wiley and Sons.

U.S. EPA, 1992, "Draft Technical Manual for Solid Waste Disposal Facility Criteria," 40 CFR Part 258.

SOIL LOSS ANALYSIS

Subject ALBION – SHERIDAN LANDFILL Project No. GE13045
By R Johnson Checked By Task No. 210
File No.
Date 1-6-97 Date Sheet 1/2

$A = R \times K \times LS \times C \times P$

WHERE:

$A =$ AVERAGE ANNUAL SOIL LOSS (TONS/ACRE)
$R =$ RAINFALL FACTOR
$K =$ SOIL ERODIBILITY FACTOR
$LS =$ SLOPE LENGTH & STEEPNESS FACTOR
$C =$ COVER/MANAGEMENT FACTOR
$P =$ EROSION CONTROL PRACTICE FACTOR.

R (RAINFALL FACTOR) FOR CALHOUN CO., MICHIGAN

$R = 120$ (SHEET 4 OF 7 USDA TECHNICAL GUIDE)

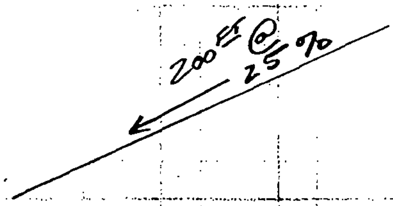
K (SOIL ERODIBILITY)

BECAUSE SOIL TYPE IS UNKNOWN FOR THE LANDFILL CAP ASSUME A WORST CASE MATERIAL (MIAMI) SOIL FROM TABLE I-2 (SHEET 5 OF 7 USDA TECHNICAL GUIDE).

$K = 0.32$

LS (SLOPE FACTOR)

→ ASSUME WORST CASE FOR SLOPE LENGTH & DEGREE



→ FROM WDOE SOLID WASTE FIGURE 4D.3:

$LS = 8.50$

Subject ALBION - SHERIDAN LANDFILL

By R. JOHNSON

Checked By

Date 1-6-97

Date

Project No. 6E13045

Task No. 210

File No.

Sheet 2/12

CP (CONTROL PRACTICE)

CP = 0.006 (ESTABLISHED GRASS, GROUND COVER 80%)

SOLVING FOR A:

$A = (R)(K)(LS)(CP)$

$A = (120)(0.32)(8.5)(0.006)$

$A = 1.95 <$ EPA MAX OF 2 TONS/ACRE

→ THIS GROUND COVER (80%) STATUS WOULD CORRESPOND TO THE FIRST FEW MONTHS OF POST CONSTRUCTION PRIOR TO FULL VEGETATION.

CP = 0.003 (ESTABLISHED GRASS, GROUND COVER 95%-100%)

SOLVING FOR A:

$A = (R)(K)(LS)(CP)$

$A = (120)(0.32)(8.5)(0.003)$

$A = 0.979 <$ EPA MAX OF 2 TONS/ACRE

→ THIS GROUND COVER (95-100%) CORRESPONDS TO POST CONSTRUCTION AFTER FULL VEGETATION.

TEMPORARY SEDIMENT BASIN IN DEVELOPING AREAS

APPENDIX I

USE OF THE UNIVERSAL SOIL LOSS EQUATION IN DEVELOPING AREAS

The following procedure for soil loss computations is an adaptation of the Universal Soil Loss Equation as presented in Agricultural Handbook No. 282, Rainfall-Erosion Losses From Cropland East Of The Rocky Mountains. A more precise computation can be made by using the full procedures given in this publication.

To predict soil losses in developing areas the simplified form of the equation is:

$$A = RCKLS$$

A - is the computed soil loss per acre per year in tons. This quantity may be converted to cubic yards by using the conversion factors found in Table I-1. All soil loss computations will be made using full years as the unit of time - that is, 1 year, 2 years, etc. - unless the more detailed procedures of Agricultural Handbook No. 282 are used.

R - is the average annual rainfall erosion index which is a measure of the erosive force of rainfall. The "R" value for urban areas is the same as that for agricultural lands and should be used in predicting annual soil losses on construction sites. Figure I-1 gives "R" values for each county in Michigan.

C - is the ratio of soil loss from land cropped under specified conditions to the corresponding loss from tilled, continuous fallow. For developing areas the following three values will represent conditions in most cases:

Well established grass or grass-legume cover	C=0.006
Weeds and wild grass cover	C=0.120
Fallow or disturbed area	C=1.000

K - is the soil erodibility factor. On construction sites, substrata materials are often exposed to water erosion so that appropriate "K" values must be used. Table I-2 give "K" values for both agricultural soils and also for the substrata material.

Limited research data show that infiltration rates and erosion losses from compacted fills do not differ greatly from those on "cuts," when slopes and surface materials are the same. Loose fills may lose less soil and water than compacted fills. Since

MICHIGAN

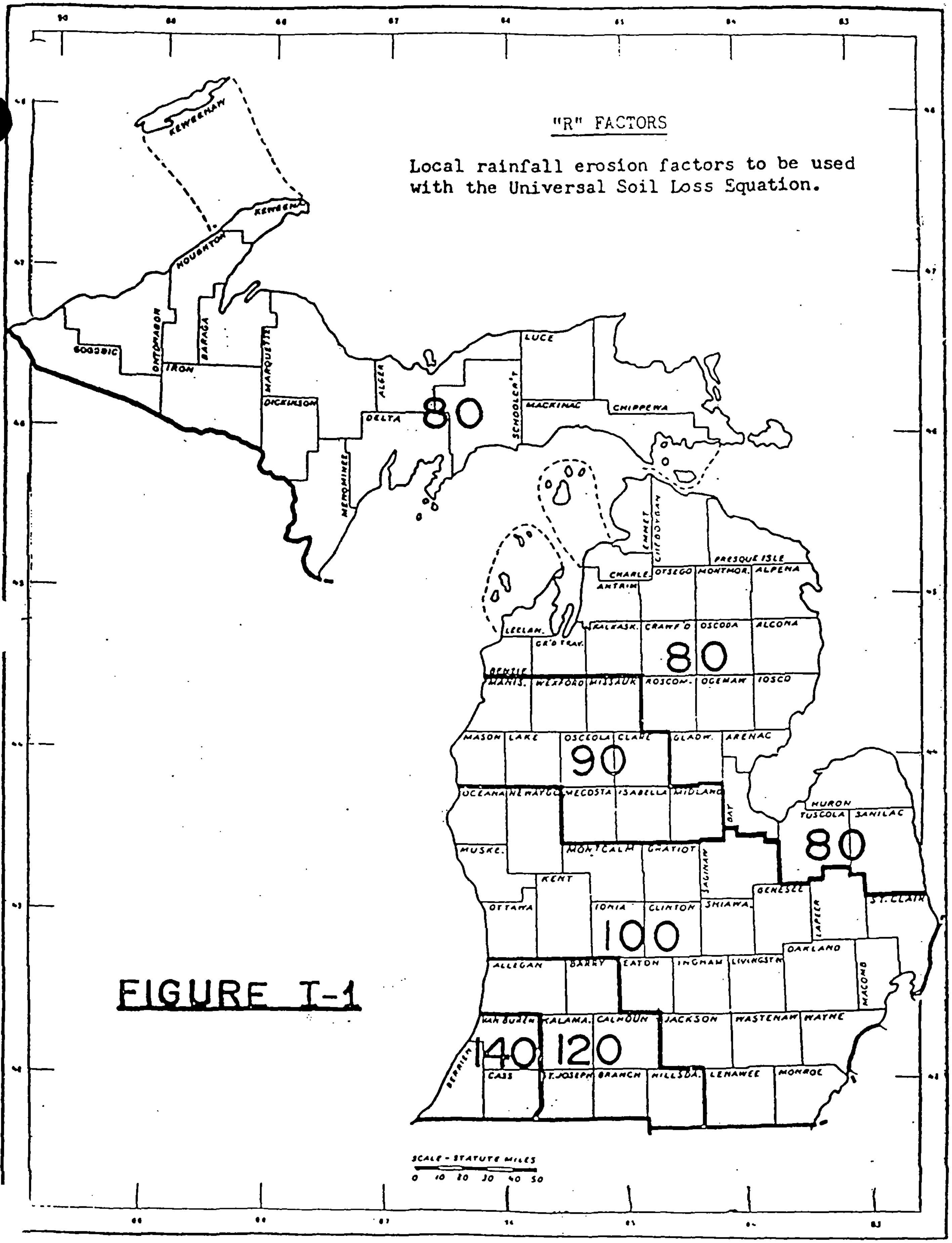


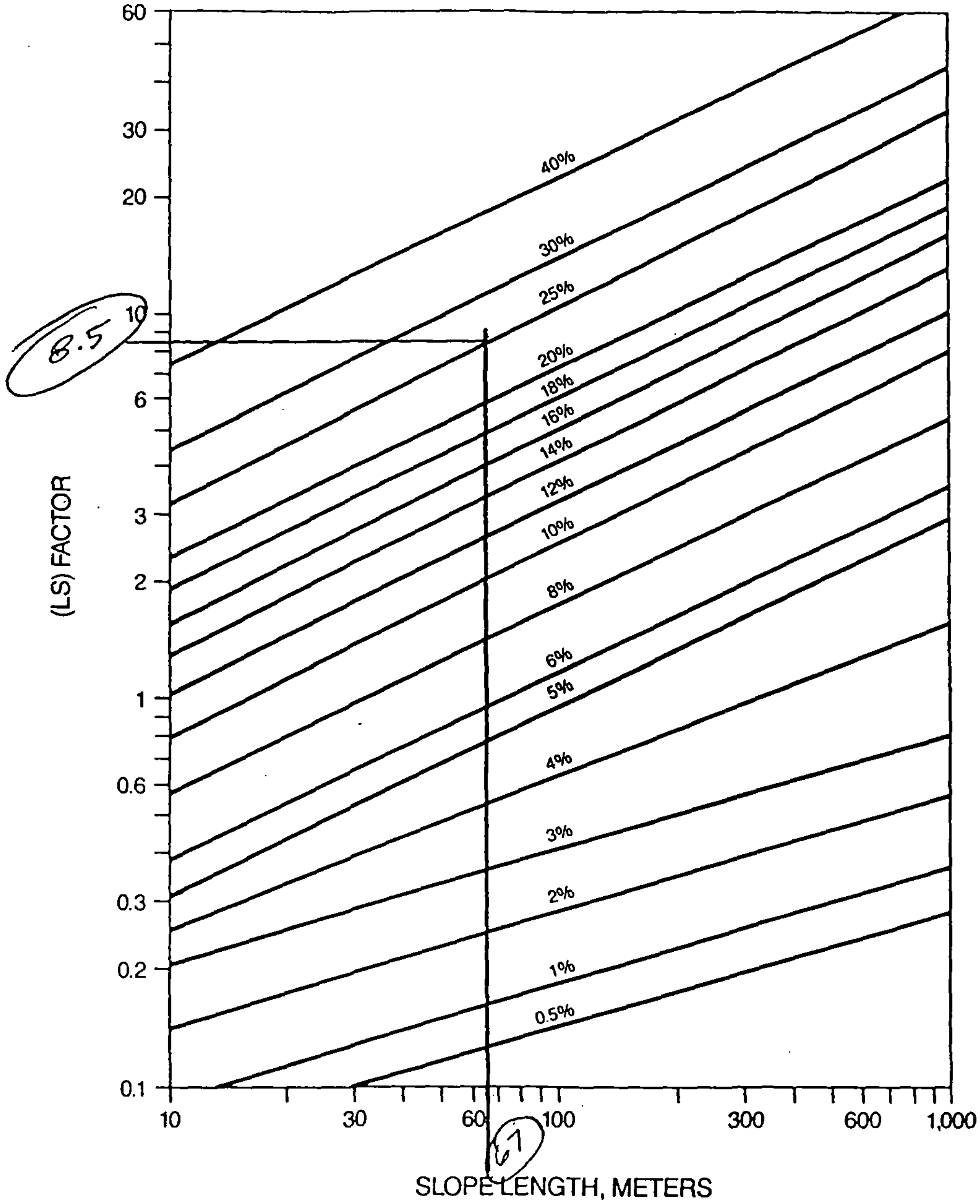
FIGURE I-1

TABLE I - 2

SOIL ERODIBILITY "K" VALUES 1/

Soil Series	Undisturbed Material 2/	Disturbed Material 2/
Blount	.43	.22
Boyer	.24	.20
Bronson	.24	.24
Celina	.37	.28
Coloma	.17	.24
Fox	.32	.32
Hillsdale	.32	.32
Kalamazoo	.32	.32
Kibbie	.37	.50
Lapeer	.28	.32
Metea	.28	.30
Miami	.37	.37
Morley	.43	.24
Oakville	.17	.17
Oshtemo	.24	.30
Ottawa	.17	.17
Owosso	.28	.37
Perrin	.24	.32
Plainfield	.17	.17
Sisson	.37	.50
Spinks	.17	.24

1/ Most of the somewhat poorly drained soils and alluvial soils are omitted from this table since they do not normally occur on slopes where erosion would be a problem.



WDOE Solid Waste

Adapted From: Novotny and Chesters, 1981

Landfill Design Manual

Figure 4D.3
Length-Slope Factor (LS) for Different Slopes

PASSIVE GAS VENT WELL SPACING ANALYSIS

Subject ASTL - PASSIVE GAS VENT PIPE SPACING   Project No. 6E15045

By RJ   Checked By   Task No. 210

File No.

Date 12-17-96   Date   Sheet 1/3

PROBLEM: DETERMINE THE PROPER SPACING FOR THE HORIZONTAL LANDFILL GAS PASSIVE VENT WELLS.

BASED ON CONVECTIVE GAS FLOW MECHANISMS AND DARCY'S EQUATION (LAMINAR FLOW ASSUMED):

$$L^2 = \frac{[K * (m_1/m_2) * (1/SW) * (P_2 - P_1) * (8760)]}{R * D}$$

WHERE:

$L =$	FLOW LENGTH (FT)
$m_1 =$	DEPTH OF SATURATED GAS FLOW (FT)
$m_2 =$	DEPTH OF REFUSE (FT)
$K =$	REFUSE PERMEABILITY (FT/HR)
$SW =$	SPECIFIC WEIGHT OF LANDFILL GAS (lbf/FT^3)
$P_2 =$	LANDFILL GAS PRESSURE (lbf/FT^2)
$P_1 =$	ATMOSPHERIC PRESSURE (lbf/FT^2)
8760 =	TIME CONVERSION (HR/YR)
$R =$	GAS PRODUCTION RATE (FT^3/YR-lbm)
$D =$	REFUSE DENSITY (lbm/FT^3)

TYPICAL INPUT VALUES:

REFUSE PERMEABILITY (K)	=	7.44×10^{-3} FT/HR
DEPTH RATIO (m_1/m_2)	=	1.0 (ASSUMED FOR SHALLOW LANDFILLS)
SPECIFIC WEIGHT (SW)	=	7.89×10^{-2} lbf/FT^3
GAS PRESSURE (P_2)	=	15.67 lb/FT^2 (GUAGE)
GAS PRODUCTION RATE (R)	=	0.04 FT^3/YR-lb
REFUSE DENSITY (D)	=	37 lb/FT^3 (1000 lb/YD^3)
ATMOSPHERIC PRESSURE (P_1)	=	14.696 lb/IN^2 (2116.224 lb/FT^2)

Woodward-Clyde

Subject ASTL - PASSIVE GAS VENT PIPE SPACING — Project No. 6E13045

By RJ — Checked By — Task No. 210

File No.

Date 12-17-96 — Date — Sheet 2/3

→ CONVERT LANDFILL PRESSURE (GUAGE) TO AN ABSOLUTE PRESSURE:

$$P_2 = P_{GUAGE} + P_{ATM} = P_{ABSOLUTE}$$

$$\therefore P_2 = 15.67 \text{ lb/FT}^2 + 2116.224 \text{ lb/FT}^2 = \underline{2131.894 \text{ lb/FT}^2}$$

→ SUBSTITUTING INTO THE ORIGINAL FLOW LENGTH EQUATION DEFINED ON SHEET 1:

$$L^2 = \frac{[K * (m_1/m_2) * (1/SW) * (P_2 - P_1) * (8760)]}{R * D}$$

$$L^2 = \frac{[(7.44 \times 10^{-3}) * (1.0) * (1/4.89 \times 10^{-2}) * (2131.894 - 2116.224) * (8760)]}{(0.04) * (37)}$$

$$L^2 = 8745.96$$

$\underline{L = 93.5 \text{ FT}}$ (FLOW LENGTH DEFINED)

→ BECAUSE GAS WILL FLOW TO A TRENCH FROM BOTH DIRECTIONS WITHIN THE LANDFILL, THE SPACING OF TRENCHES WILL BE TWICE THE GAS FLOW LENGTH AS SHOWN BELOW:

$$S = 2(L)$$

WHERE: S = TRENCH SPACING (FT)

$$\therefore S = (2)(L)$$

$$S = 2(93.5)$$

$$\underline{\underline{S = 187 \text{ FT} \approx 190 \text{ FT}}}$$

Subject ASTL - Passive Gas Vent Pipe Spacing

Project No. 6E13045

By RJ

Checked By

Task No. 210

File No.

Date 12-17-96

Date

Sheet 3/3

REFERENCES:

FUNGAROLI, A.A. AND R.L. STEINER. 1979. "INVESTIGATION OF SANITARY LANDFILL BEHAVIOR," VOLUME I, FINAL REPORT. CINCINNATI, OH: U.S. EPA, EPA 600/2-79-053a.

SCHUMACHER, M.M. (ED.). 1983. "LANDFILL METHANE RECOVERY." PARK RIDGE, NJ: NOYES DATA CORP.

FINDIKAKIS, A.N. AND J.O. LECKIE. 1979. "NUMERICAL SIMULATION OF GAS FLOW IN SANITARY LANDFILLS." PROC. ASCE, JOURN. ENV. ENG., VOL. 105, NO. EE5, PP 927-945.

TCHOBANOGLOUS, G., H. THEISEN AND R. ELIASSEN. 1977. "SOLID WASTES: ENGINEERING PRINCIPLES AND MANAGEMENT ISSUES." NEW YORK: MCGRAW-HILL.

APPENDIX 4G

SPACING PASSIVE HORIZONTAL GAS COLLECTION PIPES

4G.1 INTRODUCTION

The control of methane gas migration to below dangerous levels should be the goal of any gas control system. The Washington State Department of Ecology's Minimum Functional Standards for solid waste handling (WAC 173-304-460) require methane concentrations less than the lower explosive limits (5% by volume) at the landfill property boundary or beyond and less than 100 parts per million methane by volume in off-site structures. Therefore, upon construction or closure of a landfill, facilities to reduce methane migration or provide for ready collection of methane within the landfill may be required.

4G.2 FLOW BY DIFFUSION

Methane moves by way of diffusive (concentration gradient) and convective (pressure gradient) mechanisms. Diffusive flow of gas is in the direction of decreasing concentration. Diffusion within a landfill may occur by ordinary diffusion, Knudsen diffusion, and surface migration (Schumacher 1983). While diffusion can be an important element in lateral migration of methane, its effect is minimal where naturally occurring pressures are high within the landfill or when an induced exhaust system is used to increase the landfill pressure gradient (Moore 1979, Schumacher 1983).

4G.3 FLOW BY CONVECTION

In systems where a natural or induced pressure gradient occurs, convective mechanisms will be the primary means of gas flow (Schumacher, 1983). Therefore, the method of removing methane from a landfill is by producing a pressure/concentration sink to which the gas will flow. Darcy's Law has been used to characterize the flow of gas through the refuse (Findikakis and Leckie 1979). Using Darcy's equation and the assumption that as methane is produced it is simultaneously removed by convective mechanisms, the following mathematical expressions were derived:

Darcy's Equation:

$$q = K*m_1*(1/s.w.)*((P_2-P_1)/L) \qquad (4G\text{-}1)$$

where:
q = gas flow per unit width (ft^2/hr)
K = refuse permeability (ft/hr)
m_1 = depth of saturated gas flow (ft)
$s.w.$ = specific weight of landfill gas (lbf/ft^3)
P_1 = atmospheric pressure (lbf/ft^2)

P^2 = landfill gas pressure (lbf/ft^2)
L = flow length (ft)

The total flow out of a given width of refuse is:

$$Q = K*m_1*(1/s.w.)*((P2-P_1)/L)*w \qquad (4G\text{-}2)$$

where: Q = gas flow (ft^3/hr),
w = width of flow (ft).

Rearranging terms and isolating flow length on the left:

$$L = K*m_1*w*(1/s.w.)*((P_2/P_1)/Q) \qquad (4G\text{-}3)$$

Assuming gas flow is equal to gas production, the following equation applies:

$$Q = R*(L*w*m_2)*D/(8760) \qquad (4G\text{-}4)$$

where: R = gas production rate (ft^3/yr-lbm),
m_2 = depth of refuse (ft),
D = refuse density (lbm/ft^3),
8760 = time conversion (hr/yr).

Substituting Equation 4G-4 into Equation 4G-3 and combining flow length terms on the left:

$$L^2 = (K*(m_1/m_2)*(1/s.w.)*(P_2-P_1)*(8760))/R*D \qquad (4G\text{-}5)$$

Because gas will flow to a trench from both directions within the landfill, the spacing of trenches will be twice the gas flow length or:

$$S = 2(L) \qquad (4G\text{-}6)$$

where: S = trench spacing (ft).

Darcy's equation has been used to describe the flow of gas in several landfill gas models. However, the equation applies only to laminar flow, not to turbulent flow (Schumacher, 1983). In most systems, especially in a passive system without an induced pressure gradient, it has been shown that flow is indeed laminar.

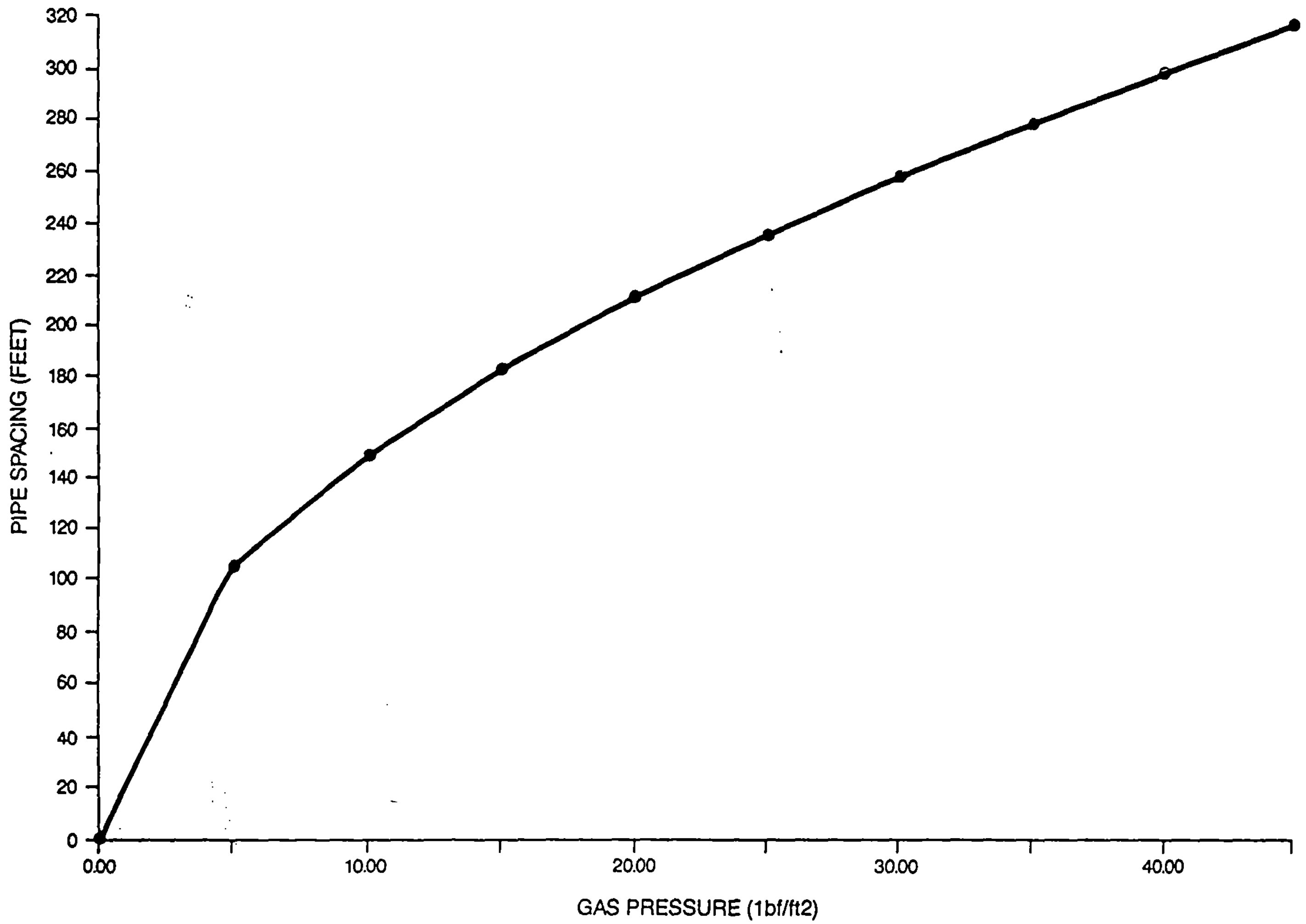
4G.4 APPLICATION

A passive system operates without artificially induced pressure gradients, such as a motor blower unit to create a negative pressure (vacuum) in extraction wells. Historically, passive venting systems have been designed primarily on judgment as to vent spacing and size. There is no well defined and accepted method in the literature that allows vent pipes to be spaced based on site specific conditions. The equations presented above were developed to calculate the required spacing of gas vent pipes given site specific conditions and a chosen maximum landfill gas pressure. Typical landfill parameters cited in several literature sources were substituted into the equations. These include the following:

Parameter	Value	Reference
Refuse permeability	7.44×10^{-3} ft/hr	(Intrinsic perm. = 1.034 darcys) Fungaroli and Steiner, 1979
Depth ratio (m_1/m_2)	1.0	assumed for shallow landfills
Specific weight	7.89×10^{-2} lbf/ft^3	Schumacher, 1983
Gas pressure (P_2)	15.67 psf	Findikakis and Leckie, 1979
Gas production rate (R)	0.04 ft^3/yr-lb	Schumacher, 1983
Refuse density	37 lb/ft^3	Tchobanoglous, et al., 1977

The graph shown in Figure 4G.1 shows the required pipe spacing versus maximum landfill gas pressure. The curve was derived by inserting the parameter values listed above in Equation (4G-5). The calculation worksheet is included as Table 4G.1. Following is an example of how this equation could be used for a shallow landfill.

If typical landfill gas pressures (16 psf) are not to be exceeded, a pipe spacing of approximately 330 feet is required. The maximum flow distance that methane must travel to reach either a collection pipe or the edge of the landfill, where it can be collected in a perimeter trench, is less than 165 feet. Vertical risers, connected to the vent piping via tee couplings, could be used to vent the gas through the final cover. The risers would incorporate a flare to burn the gases and thereby eliminate potential odor problems.



WDOE Solid Waste

Landfill Design Manual

Figure 4G.1
Gas Migration Control Pipe Spacing Versus Gas Pressure

TABLE G.1 GAS MIGRATION CONTROL - PASSIVE CONTROL SYSTEM TRENCH SPACING (BASED ON DARCY'S EQUATION)

K	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03
m1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
m2	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
P2	2.09	5.57	6.38	11.50	15.67	21.73	50.00	100.00	150.00	211.70
l	15.3	24.9	26.7	35.8	41.8	49.2	74.6	105.6	129.3	153.6
L	31	50	53	72	84	98	149	211	259	307
K	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03
m1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
m2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
P2	2.09	5.57	6.38	11.50	15.67	21.73	50.00	100.00	150.00	211.70
l	34.1	55.7	59.6	80.1	93.4	110.0	166.9	236.1	289.1	343.5
L	68	111	119	160	187	220	334	472	578	687
K	7.44E-04	7.44E-04	7.44E-04	7.44E-04	7.44E-04	7.44E-04	7.44E-04	7.44E-04	7.44E-04	7.44E-04
m1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
m2	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
P2	2.09	5.57	6.38	11.50	15.67	21.73	50.00	100.00	150.00	211.70
l	4.8	7.9	8.4	11.3	13.2	15.6	23.6	33.4	40.9	48.6
L	10	16	17	23	26	31	47	67	82	97
K	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03	7.44E-03
m1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
m2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
P2	0.00	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00
l	0.0	52.8	74.6	91.4	105.6	118.0	129.3	139.7	149.3	158.4
L	0	106	149	183	211	236	259	279	299	317

K = refuse permeability (ft/hr)
m1 = depth of saturated gas flow (ft)
m2 = depth of refuse (ft)
P2 = landfill gas pressure (psf)
l = flow length (ft)
L = trench spacing (ft)

B

APPENDIX B
FINAL REPORT

PERFORMANCE MONITORING PLAN ALBION SHERIDAN TOWNSHIP LANDFILL CALHOUN COUNTY, MI

Prepared for
Cooper Industries
Houston Texas

and

Corning, Inc.
Corning, New York

January 1997

Woodward-Clyde

38777 West Six Mile Road
Suite 200
Livonia, Michigan 48151
6E13045

TABLE OF CONTENTS

Section 1 Introduction 1-1

1.1 Site Location And Description 1-1
1.2 General License Information And Regulatory Status 1-1
1.3 Site History 1-2

Section 2 Current Site Conditions 2-1

2.1 Site Geology 2-1
2.2 Hydrogeology 2-1
2.3 Contaminants Of Concern 2-2

Section 3 Waste Characteristics 3-1

Section 4 Drum Removal And Treatment Monitoring Plan 4-1

4.1 Excavation 4-1
4.2 Drum Removal And Characterization 4-1
4.3 Temporary Storage And Transportation 4-1
4.4 Monitoring Requirements 4-2
4.5 Decontamination 4-2
4.6 Schedule 4-2

Section 5 Landfill Cap Construction Monitoring Plan 5-1

Section 6 Landfill Gas Collection System Monitoring Plan 6-1

Section 7 Groundwater Monitoring Plan 7-1

7.1 O&M Monitoring Well Locations 7-1
7.2 Monitoring Well Installation 7-1
7.3 O&M Groundwater Sampling Program 7-1
7.4 O&M Groundwater Analysis Program 7-2
7.4.1 Quarterly Groundwater Monitoring 7-2
7.4.2 Annual Groundwater Monitoring 7-2
7.4.3 Five-Year Review Groundwater Monitoring 7-2

Section 8 Quality Assurance And Quality Control 8-1

8.1 Chain Of Custody Procedures 8-1
8.2 Analytical Methods 8-1
8.3 Quality Assurance And Quality Control 8-1
8.4 Data Validation Procedures 8-1

TABLE OF CONTENTS

8.5 Requirements For Health And Safety Protocols 8-1

Section 9 Reporting **9-1**

Section 10 Schedule **10-1**

Section 11 References **11-1**

Attachments

Attachment A Standard Operating Procedures

This Performance Monitoring Plan (PMP) was prepared by Woodward-Clyde Consultants (WCC) for Corning, Inc. and Cooper Industries (the Group) to describe the technical approach, laboratory analysis and schedule of the monitoring program to be conducted at the Albion-Sheridan Township Landfill (ASTL). This plan has been prepared in accordance with the guidelines set forth in the Unilateral Administrative Order (UAO) prepared for this site (U.S. EPA, October 1995). The plan complies with Federal requirements and attains a standard performance that is equivalent to that required under Michigan Act 641 and Michigan Act 64. The information presented in Sections 1-3 was derived from the Remedial Investigation Report (WW Engineering and Science, April, 1994), the ROD and SOW.

1.1 SITE LOCATION AND DESCRIPTION

The ASTL is an inactive landfill located at 29975 East Erie Road approximately one mile east of Albion, Michigan on the eastern edge of Calhoun County (Figure 1). The site occupies approximately 18 acres. The site is surrounded by a combination of residential, agricultural, commercial and industrial properties. One residence is located immediately adjacent to the landfill to the south and five additional residences are located approximately 1,000 to 1,500 feet (ft) southwest of the landfill along East Erie Road. An active railroad track borders East Erie Road to the south of the landfill, and beyond the railroad tracks lies the North Branch of the Kalamazoo River. South of the river is agricultural land. The site does not fall within the flood plain of the river. There are wetlands south of the site adjacent to the river, but are not expected to be impacted by site activities.

The Amberton Village housing development is located adjacent to the site on the east side, with the closest residences approximately 500 ft from the landfill. Several residences and commercial businesses are located along Michigan Avenue approximately 500 ft north of the site. Immediately west of the site is undeveloped land formerly used for agriculture. The Orchard Knoll subdivision is located approximately 1,500 ft northwest of the landfill. Approximately 2,000 ft northwest of the site is a landfill associated with Brooks Foundry. Approximately one mile west is the city of Albion, with a population of 10,066 according to the 1990 census. This figure does not include approximately 1,700 students enrolled at Albion College located in the City of Albion.

1.2 GENERAL LICENSE INFORMATION AND REGULATORY STATUS

From 1966 to 1981, the landfill was privately owned and operated by Mr. Gordon Stevick. The landfill accepted municipal refuse and industrial wastes from households and industries in the City of Albion and nearby townships. In the early 1970s, the Michigan Department of Natural Resources (MDNR) approved the landfill to accept metal plating sludges. The landfill ceased operation in 1981.

In 1986, a United States Environmental Protection Agency (U.S. EPA) Field Investigation Team contractor performed a Site Screening Inspection for purposes of scoring the site per the Hazard Ranking System (HRS). EPA listed the site on the National Priorities List (NPL) in 1989. In 1991, the site was selected as a demonstration site for the presumptive remedy for CERCLA municipal landfill sites. The U.S. EPA completed the RI report in September 1994. A Record of

Decision (ROD), defining the required remedial action for the site, was signed by the Regional Administrator of U.S. EPA Region V on March 28, 1995. Respondents declined to enter into a consent decree to conduct the RD/RA for the site in accordance with the ROD and SOW, so the U.S. EPA issued an UAO on October 11, 1995.

1.3 SITE HISTORY

The Albion-Sheridan Township Landfill Site had been used as a sand and gravel borrow pit and also used for open, unpermitted dumping for an unspecified period of time prior to 1966. From 1966 to 1981, the landfill was privately owned and operated by Mr. Gordon Stevick. The landfill accepted municipal refuse and industrial wastes from households and industries in the City of Albion and nearby townships. In the early 1970s, the Michigan Department of Natural Resources (MDNR) approved the landfill to accept an estimated 6,000 cubic yards of metal plating sludges. Other materials, such as paint wastes and thinners, oil and grease, and dust, sand, and dirt containing fly ash and casting sand were also disposed of at the site. The sludge remain buried at the site. The landfill ceased operation in 1981.

2.1 SITE GEOLOGY

The geology of the site is characterized by approximately 20 to 54 ft thick glacial sediments overlying sedimentary bedrock. The glacial sediments consist of outwash sands and till, while the bedrock consists of fractured sandstone of the Marshall Formation.

Generally, the uppermost portion is composed of outwash sand from the ground surface to a depth of 10 to 30 ft below ground surface. Beneath the outwash sand is a glacial till composed primarily of silty sand with discontinuous layers containing silt and/or clay. There are no obvious clay confining layers beneath the site that are extensive enough to effectively hydraulically isolate the landfill materials from bedrock groundwater.

The uppermost bedrock beneath the site is comprised of Mississippian-aged sandstone of the Marshall Formation. The top bedrock beneath the site is generally encountered at an elevation of approximately 935 to 925 feet mean sea level (MSL). The uppermost portion of the sandstone (generally the upper 5 to 25 feet) is intensively weathered and very weak. Beneath the weathered portion, the rock is more competent and better cemented; however, it is still highly fractured. The sandstone is characterized by very fine to fine-grained quartz containing trace amounts of pyrite, mica and coal.

2.2 HYDROGEOLOGY

The results of the RI found groundwater beneath the site to be contained within the unconsolidated and bedrock aquifers. The two units are hydraulically connected in the vicinity of the site as evidenced by water level elevations. In addition, no significant clay layers or aquicludes were encountered during the drilling.

Groundwater was encountered in the unconsolidated unit throughout the site at depths of 10 to 30 feet below ground surface. Groundwater was at or very near the ground surface at the well locations adjacent to the North Branch of the Kalamazoo River. The occurrence of shallow groundwater at the site is controlled primarily by infiltration of precipitation and the characteristics of the unconsolidated unit.

The direction of groundwater flow in the unconsolidated unit is west-southwest in the vicinity of the landfill and curves in a more southerly direction near the North Branch of the Kalamazoo River. The average hydraulic conductivity of this unit was determined during the RI to be 29 ft/day. The groundwater flow velocity in the unconsolidated unit was calculated to be approximately 0.29 ft/day or 106 ft/yr.

Comparing the water level data from both bedrock wells and unconsolidated wells indicates there is a vertical component to groundwater flow. The vertical component of groundwater flow is generally downward in the northern part of the site and upward south of the site near the river. The downward gradient suggests that the northern portion of the site is an area of groundwater recharge, and the upward gradient south of the site is consistent with groundwater discharging to the North Branch of the Kalamazoo River. In addition, there is an upward gradient in the MW04 well between the deep bedrock and the shallow bedrock. This indicates that the groundwater in the deep bedrock is discharging to the shallow and weathered bedrock aquifers, thus helping to protect the deeper groundwater from contamination.

The results of the Pre-Design Studies indicated that overall, groundwater flow characteristics in the unconsolidated and bedrock units (flow direction, gradient, groundwater flow velocity) were similar with values reported in the RI.

2.3 CONTAMINANTS OF CONCERN

Waste samples from borings contained numerous constituents, including 10 VOCs, 19 semi-volatile organic compounds (SVOCs), and 11 pesticides/PCBs. Several inorganic substances were present above background levels in subsurface soils, including antimony, arsenic, chromium, copper, lead, mercury and zinc. The highest concentrations include lead at 208 mg/kg, arsenic at 13.1 mg/kg and chromium at 13.5 mg/kg. Toxicity Characteristic Leachate Procedure (TCLP) metals analysis results indicated the presence of barium and lead in the leachate, both below hazardous waste levels.

The RI found landfill constituents in groundwater extending southwest of the landfill for approximately 900 ft and extending vertically to a depth of approximately 45 ft below the water table. The unconsolidated aquifer plume contained 1,2-dibromo-3-chloropropane and antimony at concentrations above their respective federal Maximum Contaminant Level (MCL). The bedrock aquifer plume contained vinyl chloride at the MCL and arsenic above the MCL, at concentrations up to 126 ug/l.

The results of the Pre-Design Studies indicated that overall, shallow glacial monitoring well samples exhibited similar results as those obtained during the RI. The only organic compounds detected included vinyl chloride (MW03SG at 1.0 μg/L), chloroethane (MW07SG at 1.0 μg/L) and bis (2-Ethylhexyl) phthalate (MW05SG at 6.4 μg/L). Arsenic was detected in 2 wells, MW04SG and MW07SG, at concentrations of 7.9 μg/L and 13.2 μg/L, respectively.

The results of the Pre-Design Studies also indicated that overall, bedrock monitoring well samples exhibited similar results as those obtained during the RI. There were no VOCs or SVOCs detected. The only inorganic analyte detected above the 50 μg/L MCL was Arsenic in MW06SB at 130 μg/L.

The landfill is currently covered with a 1 to 4 feet thick layer of silty sand with some gravel. The cover thickness averages approximately two feet. Refuse is present within the cover material at some locations, and includes sludge, glass fragments and insulation. Refuse material is scattered at the ground surface throughout the landfill, particularly on the slopes; this material includes metal, plastic, concrete, asphalt, 55 gallon drums, wood, tires, a storage tank, and a junk crane. The landfill surface is currently subsiding at rates of 0.04 ft to 0.13 ft per year.

The landfill ranges from 16 to 35 ft thick. During drilling of wells, refuse interlayered with medium to fine sand was encountered. Landfill gases at concentrations greater than 10,000 ppm were encountered during the installation of wells and subsidence monuments on the landfill. Subsurface samples contained up to 1,500 ppm total VOCs.

The draft Drum Removal and Treatment Monitoring Plan which summarizes measures and procedures to be used during this portion of the remedial action are summarized below. The plan will be finalized by Contractor. Health and Safety requirements will be included in the health and safety portion of the Contract Documents. This plan is prepared in accordance with Section III of the SOW.

4.1 EXCAVATION

It is anticipated that work will be initiated in Level B personal protection equipment (PPE). The Contractor will establish an exclusion zone, support area and decontamination area prior to initiating excavation. Excavation will proceed with a smooth-edged bucket by excavating shallow lifts to decrease the potential for damaging buried drums. The excavator will segregate the overburden materials from the excavated material surrounding the drums. It is anticipated that air monitoring within the exclusion zone will include volatile organic compounds (VOCs) (Hnu photoionization detector with 10.2 electron volt lamp), lower explosive limit and percent oxygen. Air monitoring outside the exclusion zone will include VOCs.

4.2 DRUM REMOVAL AND CHARACTERIZATION

The Contractor will remove structurally sound drums to an intermediate staging area with appropriate equipment. Drums showing signs of degradation will be overpacked prior to moving them to the staging area. Excavated drums (including those previously removed) will be assembled in the intermediate staging area based on liquids/solids or labeled contents (if applicable) for initial characterization.

It is anticipated that the Contractor will perform an initial characterization based on general observations (labels, solids, liquids, etc.) and a "AZCAT" test which will include testing for air reactivity, color and state, water reactivity, acidic or basic properties, organic peroxide, oxidation potential and ignitability. Based on this initial characterization, the drums will be further segregated for additional characterization.

The additional characterization is expected to determine the disposal options utilizing the appropriate Resource Conservation Recovery Act (RCRA) and characterization tests (including VOCs, semi-VOCs, pesticides/herbicides, and Toxic Characteristics Leaching Potential(TCLP) metal). This characterization will determine whether the wastes can be land disposed in-place, incinerated or disposed of at an appropriate landfill. Preapproved laboratory sample containers will be decontaminated in the support zone and delivered to an appropriate laboratory for analysis.

4.3 TEMPORARY STORAGE AND TRANSPORTATION

Following characterization sampling, the drums will be stored on the surface of the landfill in a secured location where they will not be disturbed by other remedial actions. Following receipt of test results and determination of final disposal options, a proper Department of Transportation (DOT) class or division and shipping name will be assigned and all drums will be marked, labeled, packaged and manifested according to appropriate U.S. DOT regulations for transportation to the facility.

4.4 MONITORING REQUIREMENTS

It is not anticipated that additional testing will be required other than air monitoring required by the final health and safety plan and waste characterization testing. Material surrounding the buried drums will be left in place with the excavated overburden materials place on top following excavation/drum removal activities.

4.5 DECONTAMINATION

Decontamination procedures will be as specified in the health and safety plan included with the Contract Documents and will occur following completion of all excavation. All trash and testing debris will be placed inside poly bags, sealed and packed in a steel or poly pail for disposal.

4.6 SCHEDULE

It is expected that drum excavation will occur prior to or during the early stages of landfill cap construction activities in order to reduce the threat of exposure or potential release from the temporarily secured drums.

The Construction Quality Assurance Plan (CQAP) included in Appendix C details monitoring and sampling requirements prior to, during and after construction of the landfill cap and landfill gas collection system. In addition, air emission monitoring requirements during landfill cap and gas collection system construction will be detailed in the Health and Safety Plan.

The Statement of Work (SOW) for the remedial action at the ASTL establishes the requirements for performance of the remedial action. One of these requirements is the following:

At all times during the performance of the remedial action, air emissions shall not exceed a total cancer risk of 1 x 10^{-6} at the fenceline, using risk calculation methods set forth in Risk Assessment Guidance for Superfund. In addition, the air emissions shall not exceed any Applicable or Relevant and Appropriate Requirements (ARARs).

During the Pre-Design Studies, WCC used the Landfill Air Emissions Estimation Model (USEPA, 1991, Landfill Air Emissions Estimation Model, EPA-600/8-90-085a, April 1991 and *Air/Superfund National Technical Guidance Study Series, Models for Estimating Air Emission Rates from Superfund Remedial Actions* USEPA. 1993) to predict chemical-specific landfill gas generation rates and downwind concentrations of these chemicals. It was demonstrated that the total cancer risk level of 1 x 10^{-6} will not be exceeded at the fenceline from/during RA activities or waste consolidation activities.

The Pre-Design Study determined that the SOW requirements will be met by a passive gas venting system without any controls on gas emissions. As such, no gas emission monitoring other than that to be detailed in the Health and Safety Plan is planned. It should be noted that the Landfill Air Emissions Model predicted a decreasing trend in the gas production rate starting approximately 2 years after landfill closure (1981).

The purpose of the long-term Operation and Maintenance (O&M) groundwater monitoring is to assess the effectiveness of the remedial action/cap integrity by detecting changes in the chemical concentration of the groundwater at and adjacent to the site.

7.1 O&M MONITORING WELL LOCATIONS

Designated groundwater monitoring wells and seven drinking water wells will be included in a quarterly O&M monitoring program. Also, designated (along with two wells yet to be installed) groundwater monitoring wells will be included in an annual O&M monitoring program. Additionally, designated groundwater monitoring wells will be included in a 5 year review monitoring program.

7.2 MONITORING WELL INSTALLATION

The two groundwater monitoring wells (MW09DB and MW15SB) will be constructed and developed in accordance with industry standards and the attached Standard Operating Procedures (SOP) 1 and 2. Riser pipe and well screen materials will be 2-in. diameter, poly vinyl chloride. The monitoring wells will be fitted with 5-ft-length of screens with #10 factory cut slot screens. MW15SB will be vertically sampled as detailed in SOP-01. Monitoring installation is expected to occur after an agreement/easement with the current landowner (Mr. Dick Gill) has been reached.

7.3 O&M GROUNDWATER SAMPLING PROGRAM

Water level measuring and groundwater sampling procedures will be consistent with the SOW and relevant requirements of Michigan solid waste rules under Act 641 and hazardous waste rules under Act 64. A detailed description of these procedures is presented in the Standard Operating Procedures (SOPs) contained in Attachment A which are similar to the procedures detailed in the RD Work Plan FSP (WCC, June, 1996). However, a dedicated low flow (less than liter/min) bladder pump will be installed at each monitoring well for groundwater sampling. Water in the screened interval of lower aquifer wells will be isolated from water in the casing by use of an inflatable packer to avoid having to purge the entire water column. The sampling will utilize Micropurge techniques to minimize turbidity and mixing of the stagnant water in the well casing with water in the water screen collected for the analyses. Sampling and field analyses procedures are presented in SOP-5.

The O&M monitoring and drinking water well quarterly and annual sampling/analysis events will commence following EPA and MDEQ approval of the Final Construction Report.

7.4 O&M GROUNDWATER ANALYSIS PROGRAM

7.4.1 Quarterly Groundwater Monitoring

The quarterly groundwater monitoring program will consist of: 1) field parameters, 2) arsenic, and 3) ammonia. Field parameters include: groundwater depth/elevation before purging (except for drinking water wells); temperature; pH; specific conductivity; Eh; and dissolved oxygen.

The quarterly monitoring of the seven drinking water wells will consist of: 1) field parameters, 2) Special Analytical Services (SAS) low level organics, 3) SAS low level metals, cyanide, mercury (unfiltered), and 4) SAS parameters: chloride, sulfate, nitrate/nitrite, and ammonia.

7.4.2 Annual Groundwater Monitoring

The annual monitoring will be done in accordance with the SOW and consist of: 1) field parameters, and 2) chemicals of concern. Chemicals of concern will be 5 Target Analyte List (TAL) chemicals (Aluminum; Arsenic; Cobalt; Manganese; and Nickel), and 2 Target Compound List (TCL) volatile organic compounds (VOCs - Benzene and Vinyl Chloride), and antimony, ammonia and 1,2-Dibromo-3-chloropropane.

7.4.3 Five-Year Review Groundwater Monitoring

Designated monitoring wells will be sampled and analyzed for TCL organics, TAL inorganics and 1,2-dibromo-3-chloropropane to assist the EPA in meeting the requirements of Section 121(c) of CERCLA for the first five year review of the site. Five-year review groundwater monitoring will occur approximately 50 to 52 months after approval of the Final Design.

After the groundwater analytical data from the initial year of groundwater sampling has been evaluated, analytes will be removed from the list if the provisions of the generic residential cleanup criteria for the health based drinking water value for Public Act 307 amended, June 1995 Act 451 are met with the approval from the EPA and MDEQ. This list will be reevaluated each year upon the review of the full TCL and TAL laboratory results. A new compound may be added to the list for quarterly sampling parameters if it appears that the compound is originating from the landfill. A compound maybe dropped from the list if is not observed during the next consecutive quarterly sampling events above the appropriate residential or industrial cleanup criteria.

Section 8 summarizes the quality assurance and quality control measures and health and safety requirements that will be utilized.

8.1 CHAIN OF CUSTODY PROCEDURES

Chain of Custody procedures are described in SOP-03 in Attachment A.

8.2 ANALYTICAL METHODS

Laboratory analysis of the groundwater samples and method detection limits will be in accordance with guidance published by the MDNR in Michigan Environmental Response Act (MERA) Operational Memorandum #6, Revision #3 dated February 4, 1994. Analysis and method detection limits are expected to be similar to those detailed in the Remedial Design Work Plan (WCC, June, 1996).

8.3 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance/quality control (QA/QC) procedures will be implemented to ensure the accuracy of the analytical data acquired during the monitoring program. The QA/QC procedures to be implemented in the field will be described in the O&M Quality Assurance Project Plans (QAPP) which will be similar to the RD QAPP (WCC, 1996).

8.4 DATA VALIDATION PROCEDURES

Data validation procedures will be performed for both field and laboratory operations as described in the O&M QAPP.

8.5 REQUIREMENTS FOR HEALTH AND SAFETY PROTOCOLS

All work conducted at the Site shall be done in accordance with the SOW and requirements of Michigan solid waste rules under Act 641 and hazardous waste rules under Act 64. All contractors or subcontractors performing work at the site shall comply with the Health and Safety Plan, applicable local, state and federal laws and regulations and specific SOPs. Requirements for Health and Safety Protocols will be described in the Construction Health and Safety Plan (CHASP).

The field and laboratory data will be reported to the U.S. EPA and MDEQ in the quarterly or semiannual report after completing the data validation. The data will be presented in both tabular form and plotted on the site map for visual reference.

The initial groundwater sampling and analysis event will occur after cap construction is completed following EPA approval of the Final Construction Report. Thereafter, groundwater sampling and analysis will be conducted on a quarterly basis for the first year of the monitoring program.

Samples will be analyzed for selected TAL and TCL parameters for each sampling event. The sampling schedule may be modified in the future with the approval of U.S. EPA and consultation of MDEQ.

Woodward-Clyde Consultants, Remedial Design (RD) Work Plan, Albion-Sheridan Township Landfill, Calhoun County, MI, Vol. 1 and 2, June, 1996.

WW Engineering & Science, Final Remedial Investigation Report of the Albion-Sheridan Township Landfill, Albion, Michigan, April, 1994.

WW Engineering & Science, Final Presumptive Remedy Feasibility Study Report of the Albion-Sheridan Township Landfill, Albion, Michigan, September, 1994.

Woodward-Clyde Consultants, Pre-Design Studies, Albion-Sheridan Township Landfill, Calhoun County, MI, November, 1996.

U.S. EPA Region V (1995) Statement of Work for Remedial Design and Remedial Action at Albion-Sheridan Township Landfill Site, Calhoun County, Michigan.

U.S. EPA Region V (1995) Declaration for the Record of Decision, Albion-Sheridan Township Landfill Site, Albion, Michigan.

U.S. EPA Region V (1995) Unilateral Administrative Order For Remedial Design and Remedial Action, Albion-Sheridan Township Landfill, City of Albion, Corning Glass, Inc., Decker Manufacturing, Inc., and Cooper Industries, Inc., Respondents.

U.S. EPA, Landfill Air Emissions Estimation Model, EPA-60018-90-085a, April, 1991.

U.S. EPA, Air (Superfund National Technical Guidance Study Series, Models for Estimating Air Emission Rates from Superfund Remedial Actions, 1993.

U.S. EPA, Guideline on Air Quality Models, 1987.

ATTACHMENT A

[redacted] STANDARD OPERATING PROCEDURES
PERFORMANCE MONITORING PLAN
ALBION-SHERIDAN TOWNSHIP LANDFILL
ALBION, MICHIGAN

Prepared for
The Albion-Sheridan Landfill Group
Albion-Sheridan Township Landfill Site
January 1997

Woodward-Clyde Consultants
38777 West Six Mile Road, Suite 200
Livonia, Michigan, 48152

Project Number 6E13045

TABLE OF CONTENTS

SOP-01 MONITORING WELL INSTALLATION IN BEDROCK AQUIFER

1.0 OBJECTIVE
2.0 EQUIPMENT
3.0 DRILLING PROCEDURE

3.1 Vertical Aquifer Sampling

4.0 MONITORING WELL MATERIALS

4.1 Surface Casting
4.2 Cement Bentonite Grout
4.3 Well Casings
4.4 Well Screens
4.5 Filter Pack
4.6 Bentonite Seal

5.0 MONITORING WELL INSTALLATION PROCEDURES

5.1 Monitoring Well Installation

SOP-02 MONITORING WELL DEVELOPMENT

1.0 OBJECTIVE
2.0 EQUIPMENT
3.0 PROCEDURES
4.0 DEVELOPMENT CRITERIA
5.0 DOCUMENTATION

SOP-03 SAMPLE CUSTODY PROTOCOLS AND FIELD DOCUMENTATION

1.0 SAMPLE CHAIN-OF-CUSTODY PROTOCOL
2.0 PACKING AND SHIPPING PROTOCOL
3.0 SAMPLE PRESERVATION
4.0 SAMPLE IDENTIFICATION
5.0 SAMPLE LABELING
6.0 FIELD DOCUMENTATION

TABLE OF CONTENTS (CONT.)

SOP-04 CALIBRATION AND MAINTENANCE PROCEDURES

1.0 FIELD INSTRUMENTS AND EQUIPMENT CALIBRATION
2.0 PREVENTATIVE MAINTENANCE

SOP-05 QUALITY ASSURANCE/QUALITY CONTROL SAMPLING

1.0 DUPLICATE SAMPLES
2.0 BLANK SAMPLES
3.0 MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES

SOP-06 WATER LEVEL MEASUREMENTS

1.0 OBJECTIVE
2.0 EQUIPMENT
3.0 PROCEDURE

3.1 DECONTAMINATION

4.0 DOCUMENTATION

SOP-07 GROUNDWATER SAMPLING

1.0 OBJECTIVE
2.0 EQUIPMENT
3.0 PROCEDURE

3.1 EQUIPMENT DECONTAMINATION
3.2 INSTRUMENT CALIBRATION
3.3 WELL PURGING
3.4 SAMPLE COLLECTION
3.5 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES AND SAMPLES

4.0 SAMPLE IDENTIFICATION AND HANDLING
5.0 DOCUMENTATION

TABLE OF CONTENTS (CONT.)

5.1 FIELD SAMPLING DATA SHEET

5.2 FIELD NOTES

5.3 WELL VOLUME CALCULATIONS

6.0 CALIBRATION

6.1 pH METER
6.2 CONDUCTIVITY METER
6.3 REDOX POTENTIAL

SOP-08 FIELD EQUIPMENT DECONTAMINATION

1.0 OBJECTIVE
2.0 EQUIPMENT
3.0 GENERAL
4.0 PROCEDURES
5.0 HANDLING OF DECONTAMINATION FLUIDS

LIST OF TABLES

TABLE SOP-4-1 FIELD EQUIPMENT CALIBRATION AND MAINTENANCE
TABLE SOP-7-1 CONTAINER TYPES AND PRESERVATION METHODS

LIST OF FIGURES

FIGURE SOP-1-1 LOWER AQUIFER MONITORING WELL SHEET
FIGURE SOP-1-2 LOWER AQUIFER MONITORING WELL CONSTRUCTION DIAGRAM
FIGURE SOP-2-1 WELL DEVELOPMENT FORM
FIGURE SOP-3-1 CHAIN-OF-CUSTODY RECORD
FIGURE SOP-3-2 SAMPLE LABEL
FIGURE SOP-3-3 SAMPLE BORING LOG
FIGURE SOP-3-4 SAMPLE GROUNDWATER SAMPLING SHEET

SOP-01

MONITORING WELL INSTALLATION IN BEDROCK AQUIFER

1.0 OBJECTIVE

This document describes the standard procedure to install and develop a monitoring well or piezometer in the lower (bedrock) aquifer in a landfill environment. SOP-8 describes the decontamination procedures which are applicable to this SOP.

2.0 EQUIPMENT

The following is a list of equipment and well materials for the well installations:

- Drill rig with 6-in tricone bit.
- Temporary casing (4" steel).
- High pressure steamer/sprayer.
- Weighted tape measure.
- Water level probe.
- Drums for containment of cuttings.
- Health and safety equipment (see HASP).
- Field book.
- Location map.
- Boring log form.

3.0 DRILLING PROCEDURE

All drilling equipment, including the drill rig, water tanks, and all downhole equipment will be decontaminated according to SOP-8. Downhole equipment will be decontaminated between boreholes, and other equipment such as the drill rig will be decontaminated between different work areas. Drilling fluid water will be obtained from the local public water supply system. The water supply was previously sampled for contaminates of concern (TCL Organics, TAL

Inorganics and 1,2-Dibromo-3-Chloropropane) during Pre-Design Studies to ensure cross contamination does not occur from this source and it is not anticipated that this will be required again.

1. Identify the areas having buried structures and utility lines with the appropriate local authorities.

2. Advance the borehole and temporary casing (to bedrock) from the ground surface to the required depth using hollow stem auger (HSA) and rotary methods with water as the drilling fluid and log the cuttings. The diameter (O.D.) of the tricone bit will be approximately 6 inches and the diameter of the HSA (I.D.) will be approximately 4 1/4 inches.

3. If required (only in MW15SB), install temporary well with packer, develop and collect sample, repeat as necessary (see Section 3.1).

4. Conduct 5 foot interval NX Coring to verify that competent bedrock is present.

5. Install monitoring well/remove temporary casing (see 5.0).

3.1 Vertical Aquifer Sampling

Vertical aquifer sampling (VAS) in MW15SB will be accomplished using the temporary well method and will commence within the first 10 foot interval upon encountering the uppermost aquifer. When the boring and temporary casing have been advanced 10 feet into the uppermost aquifer, a temporary well casing and screen with a packer above the screen will be used to sample the lower 5 foot portion of the boring. The temporary well will be developed as described in SOP-02 and a groundwater sample will be collected. Field analysis of the sample will include the field parameters as described in Section 7.4 of the Performance Monitoring Plan.

This sequence will continue to the base of the weathered bedrock. Five foot interval NX Coring will be performed upon encountering bedrock to determine depth to competent bedrock.

The drilling/sampling sequence will stop upon encountering competent bedrock. Field results showing the greatest abnormality compared to results within the other sampling intervals will determine the final well screen placement. Previous work at the site has shown Eh and dissolved oxygen to be indicator parameters which correlate and/or influence the concentrations of arsenic in groundwater. Further, results of the RI (April, 1994) found that the results of VAS did not indicate a preferred sampling zone within the unweathered bedrock and all shallow bedrock wells were set approximately ten feet below the top of the unweathered bedrock.

Following determination of final screen placement depth, the monitoring well will be installed as described in Section 5.0.

4.0 MONITORING WELL MATERIALS

4.1 Surface Casing

Surface casing will consist of new, 6-inch diameter steel protective casings with a steel protective locking cap.

4.2 Cement -Bentonite Grout

A mixture of water/cement/bentonite at a 6 gallon/94 pounds/4.7 pounds (5% by weight of cement) ratio will be used to grout the annular space between the surface casing and the borehole. The annular space between the well casing and the borehole and surface casing will be grouted from the top of the bentonite seal to ground surface. The cement-bentonite grout will be mixed in a powered mechanical grout mixer according to the manufacturer's specifications.

4.3 Well Casings

Well casings will consist of new, threaded, flush-joint, 2-inch (ID) PVC. The well casing will extend from the top of the well screen to approximately 2 feet above ground surface. The tops of all well casings will be fitted with threaded caps that can be easily removed by hand.

4.4 Well Screens

The screens will consist of 5-foot long, new, flush-threaded joint PVC screen with a factory cut 0.010-inch slot. A threaded cap will be provided at the bottom of the screen.

4.5 Filter Pack

The filter pack material will be sand with a 16-40 size gradation. The filter pack will extend approximately 2 feet above the top of the screen, but in no case less than 6 inches above the screen. The final depth to the top of the filter pack will be measured by using a weighted tape measure.

4.6 Bentonite Seal

A bentonite seal will be installed above the filter pack. The seal will consist of a layer of commercially-available bentonite pellets.

5.0 MONITORING WELL INSTALLATION PROCEDURES

5.1 Monitoring Well Installation

Monitoring well installation will begin after formation water and fine grained sediment have been flushed by pumping drilling water through the rods.

The borehole depth will be measured to the nearest 0.1 foot. The casing and screen will be installed in the boring and cut off 2 ft above ground. The portion of the well casing cut off at the top will be measured and subtracted from the total length supplied to determine the total well assembly length.

Once the well assembly is in place, the filter pack will be added slowly to the zone below the water level in the borehole by tremie pipe as the temporary casing is removed. Depth measurements of the top of the filter material will be taken periodically in the well annulus as the filter pack is placed. The top of the filter pack will be measured by a weighted tape measure.
A minimum 2-foot thick bentonite pellet seal will be installed immediately above the filter pack. The bentonite pellets will be added slowly to reduce the chances for bridging of the pellets. The completed bentonite seal will be allowed to hydrate for approximately 30 minutes before proceeding with the grouting operation.

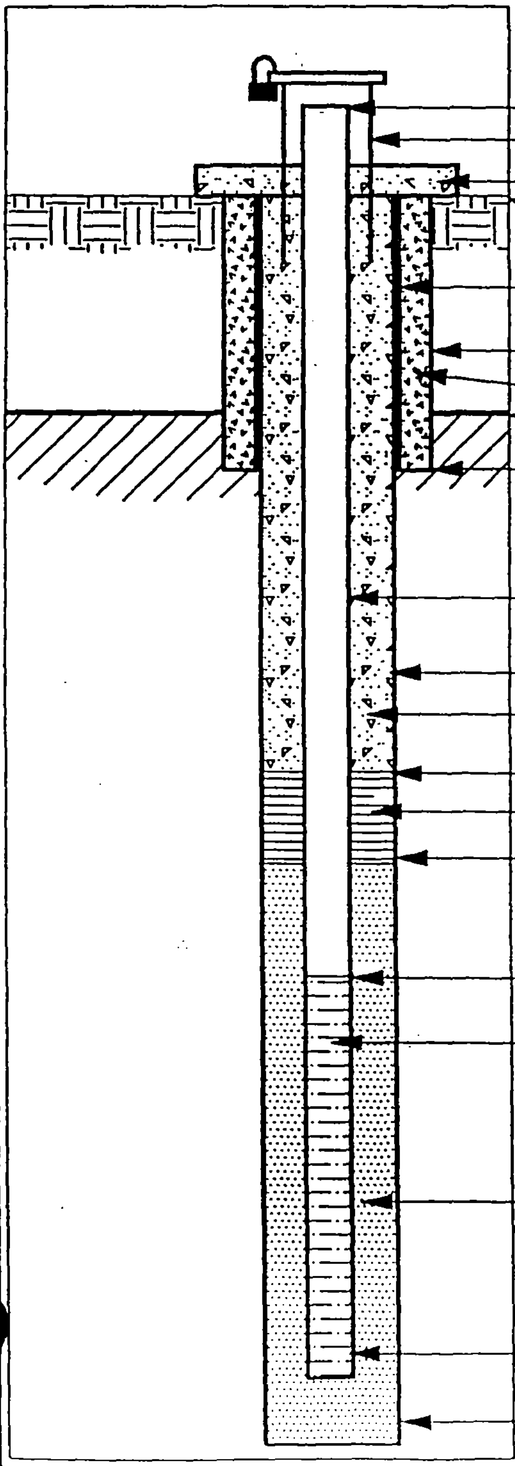
Cement-bentonite grout backfill will be placed from the top of the bentonite seal to 1 1/2 to 3 feet below ground surface. The grout will be tremied into the well annulus using a side-discharge tremie until it is completely full. After settlement of the bentonite grout has been allowed for 24 to 72 hours, the protective steel casing will be embedded in nonshrink concrete. The cement- will occupy the upper 1 1/2 to 3 feet of the well annulus to anchor the protective casing. Protective posts will be installed around MW15. Protective posts are not anticipated around MW09DB but three posts will be emplaced if vehicular traffic could impact the integrity of the well.

The well will be developed in accordance with SOP-02 after removing the volume of drilling fluids lost to the formation during drilling. Dedicated, low-flow, bladder pumps will be installed in each well in accordance with SOP-07 and manufacturer's specifications prior to initiation of the O&M sampling program.

FIGURE SOP-1-1
LOWER AQUIFER MONITORING WELL SHEET

MONITORING WELL SHEET

Project:	Location:	Driller:
Project Number:	Well Number:	Drilling Method:
Elevation:	Date:	Date Completed:
Logged By:		Development Method:
		Date Completed:



Key padlock type and number: ____________

Elevation Top Of Casing: ____________

Type of protective casing: ____________

Type of surface seal: ____________

Ground Elevation: ____________

Surface Casing I.D.: ____________

Casing Material: ____________

Borehole Diameter: ____________

Type of grout: ____________

Depth Top of Bedrock: ____________

Depth Bottom of Surface Casing: ____________

Casing I.D.: ____________

Casing Material: ____________

Borehole Diameter: ____________

Type of grout: ____________

Depth top of seal: ____________

Type of seal: ____________

Depth top of sand pack: ____________

Depth top of screen: ____________

Type of screen: ____________

Slot size X length: ____________

I.D. of Screen: ____________

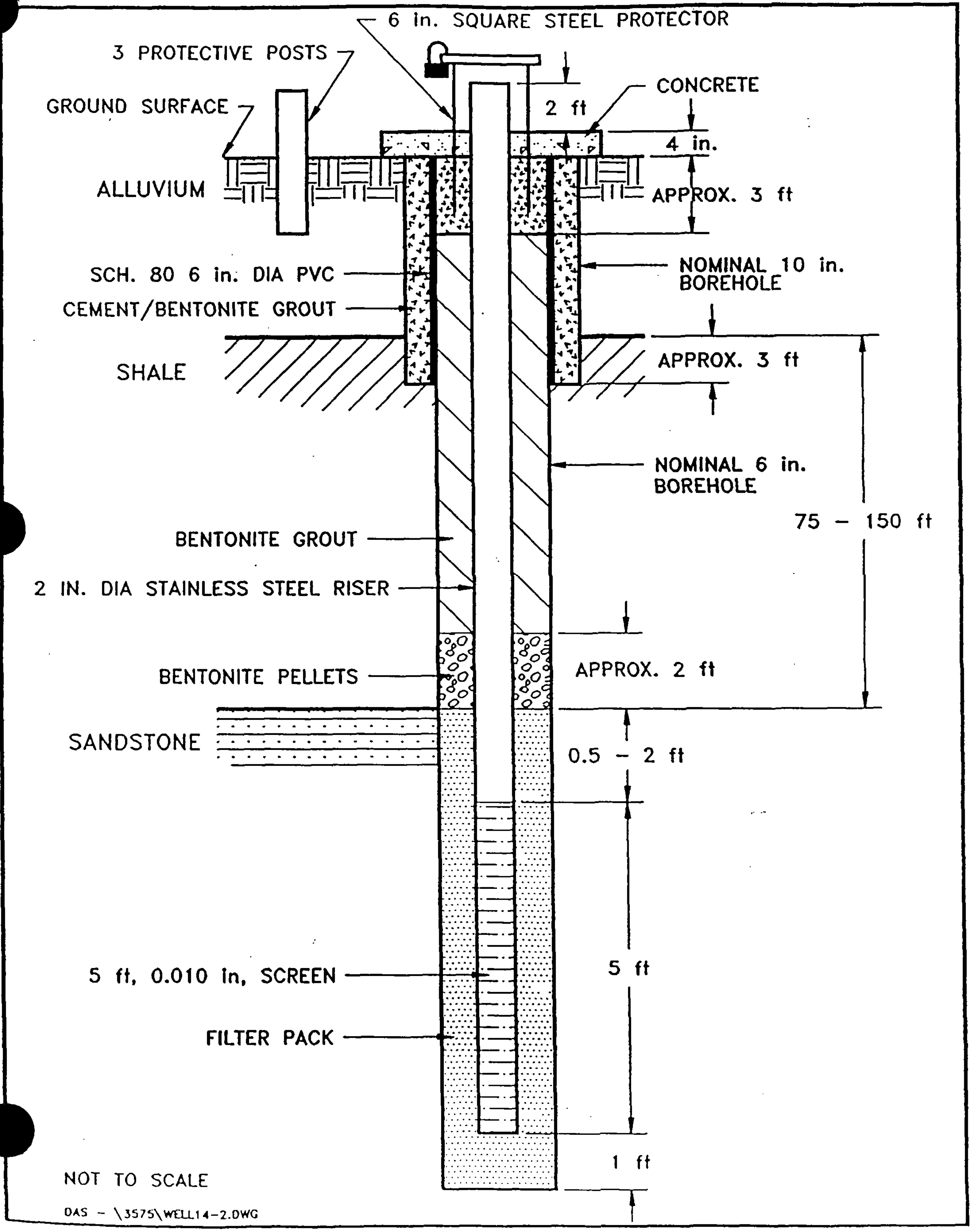
Type of sand pack: ____________

Depth bottom of screen: ____________

Total depth of hole: ____________

DAS – WELL14-1.DWG

FIGURE SOP-1-2
LOWER AQUIFER MONITORING WELL CONSTRUCTION DIAGRAM



SOP-02
MONITORING WELL DEVELOPMENT

1.0 OBJECTIVE

Monitoring well development is the process by which the well drilling fluids and mobile particulates are removed from within and adjacent to the newly installed wells. The objective of a completed well development activity is to provide groundwater inflow that is as physically and chemically representative as possible of the aquifer that is open to the piezometer or well.

2.0 EQUIPMENT

The following is a list of well development and associated equipment:

- Stainless steel, Teflon® bailer or dedicated disposable bailer.
- Inertial or submersible pump.
- Water quality test kit (pH, temp, dissolved oxygen and conductivity).
- Clear plastic sheeting or vinyl sheeting which may be decontaminated.
- Disposable latex or vinyl gloves.
- Nonphosphate, lab detergent (e.g., Liquinox).
- Containers for development.
- Water level probe - sufficiently accurate to measure water levels to the nearest 0.01 foot.
- Weighted tape measure - sufficiently accurate to measure depths to the nearest 0.10 foot.
- Distilled water.
- Field book and field forms.
- Health and safety equipment.
- Calculator.

3.0 PROCEDURES

Perform the development as soon as practical after well installation, but no sooner than 48 hours after grouting or pad installation is completed. The equipment for well development may be an inertial pump, bottom discharge/filling bailer, or submersible pump.
The water level measurement along with the total depth measurement will be used to determine the volume of water in the well casing. Water-level measurement is described in SOP-06, Water Level Measurements. Well casing calculations are presented in Section 4.0 of this SOP.

Formation water and fines will be evacuated by vigorously lowering and raising the pump or bailer intake throughout the water column to create a surging action. Development equipment, including bailers and pumps, will be decontaminated before well development begins and between well sites according to SOP-08, Field Equipment Decontamination.

4.0 DEVELOPMENT CRITERIA

Development shall proceed in the manner described herein and continue until the following are met:

- Removal of a minimum of five well casing volumes. Typical well casing volume calculations for a 2-inch well are as follows:
  gal/ft x ___(linear ft of water) = gallons of water
- Record pH, temperature, and specific conductance after three consecutive well casing volume measurements (i.e., consecutive temperatures that are within 1°C, and pH readings that are within 0.2 units) and consecutive conductivity readings fall within 10 percent of each other. The calibration and use of these field instruments is described in SOP-04, Calibration and Maintenance Procedures.
- If water is used during monitoring well drilling, the total fluid added will be calculated, and the fluid lost in the borehole during drilling will be recovered in addition to the five well casing volumes.
- The sediment in the well has been removed.

5.0 DOCUMENTATION

The following well development information will be recorded on the Well Development Form **(Figure SOP-2-1)**:

- Well I.D. and location survey coordinates.
- Date(s) of well installation.
- Date(s) and time of well development.
- Well designation.
- Screened interval.
- Well stick-up.
- Static water level from measuring point.
- Total depth from measuring point.
- Volume of well casing volume.
- Quantity of water used during drilling.
- Depth from top of well casing to top of sediment inside well, before and after development.
- Type of pump and/or bailer.
- Field measurements.
- Physical description of removed water throughout development (color and turbidity).
- Quantity of water removed and time for removal (incremental and total values).

FIGURE SOP-2-1 WELL DEVELOPMENT FORM

Recorder's Name and Title ____

Well ID ____

Survey location coordinates: North __ East ____

Date this report ___________ Date well installation _____________ Date well development ___

Well designation: ____

Ground elevation: Est: ____ Survey: ___

Screened interval: ________________________ Formation: ____________________

Measuring point (MP): Top of well casing/other: ______________________ Well stick up: ___

Water level (below MP): Start: ____ End: ___

Well depth (below MP): __________________________ Water elevation (BGS) _______

Method used to measure water level: _________________ Estimated recharge rate: _______

Volume of saturated annulus (assume 30 percent porosity): __________________________

Volume Calculation: ____

Quantity of water used during drilling: ____

Depth of sediment (below MP): Before: ____________________________________ After: ___

Development equipment: ____

Sampling equipment: ____

pH meter No. ____________ Calibration: ____

Specific conductance meter No.: ____________________________________ Calibration: ___

Time	Pumping Rate gpm	pH	Temp. °C	S.C. umhos/cm a: °C	Cum. Vol. of H_2O Removed		Physical Description of Water
					Gallons	Casing Vols.	

Comments: ____

____

SOP-03

SAMPLE CUSTODY PROTOCOLS AND FIELD DOCUMENTATION

1.0 SAMPLE CHAIN-OF-CUSTODY PROTOCOL

Possession of samples collected in the field will be traceable from the time of collection until they are analyzed by a laboratory or disposed. Chain of custody procedures will be followed to maintain and document sample possession. A chain of custody record (**Figure SOP-3-1**) will be utilized by field personnel to document possession of all samples collected for chemical analysis. This record will include, but is not limited to, the following information:

- Project name and number.
- Name(s) and signatures of samplers.
- Sample identification number and location.
- Date and time of collection.
- Number and type of containers.
- Required analyses.
- Preservatives.
- Courier.
- Signatures documenting change of sample custody.

Chain of custody forms will accompany samples at all times. When transferring possession of the samples, the individuals relinquishing and receiving the samples will sign, date, and note the time of transfer on the record. The chain of custody will be placed in a sealed plastic bag and taped to the inside of the sample chest. The sample chest will be sealed prior to presentation to the delivery service. A commercial delivery service (i.e., Federal Express) will be identified by company name only. The delivery service is not required to sign the chain of custody. The original chain of custody which accompanies the sample to the analytical laboratory will be returned to the contractor with the analytical results and will be placed with the project file. A copy of each record will be retained by the sample custodian in the field and by the laboratory.

Samples will be tracked by the analytical laboratory in accordance with procedures specified in the Quality Assurance Project Plan.

2.0 PACKING AND SHIPPING PROTOCOL

This section describes packing and shipping procedures used for environmental samples. The procedures meet Department of Transportation requirements.

All samples will be classified as environmental and will be packaged using the following procedures to prevent breakage or leakage of sample container contents.

1. Check all labels for legibility and accuracy, replace labels if necessary.

2. Ensure that all labels are covered with wide cellophane tape to protect labels during shipping.

3. Visually check the outside surface of the containers for proper decontamination. If any containers appear to be soiled, decontaminate again.

4. Check all container lids and tighten if necessary.

5. Wrap sample containers with packaging material to prevent breakage during shipping.

6. Place sufficient packaging material in bottom and around the sides of the shipping cooler (sample chest).

7. Place wrapped samples in the cooler. Complete and check chain of custody forms during packaging following the protocol presented in Section 1.

8. Add ice packs to the cooler in quantities adequate to maintain 4°C temperature during shipping. If ice is used, it should be placed in sealed plastic bags.

9. Fill excess space in cooler with packing material to prevent movement of the sample containers. Styrofoam "peanuts" or other material may be used.

10. Chain of custody forms which accompany the samples to the laboratory are to be placed inside a plastic bag, sealed and taped to the inside of the cooler lid.

11. The following markings are to be placed on the top of the cooler:

    - "This End Up" labels or arrows
    - Shipper's name and address

12. The cooler is to be closed and sealed with filament tape in a manner to prevent inadvertent opening during shipment.

13. Two custody seals are to be placed on the cooler in an area that would indicate if tampering had occurred. Alternatively, lockable coolers are to be used with one custody seal.

14. A completed label for shipping by express carrier is to be attached to the top of the cooler. A copy of the shipping form is to be retained by the sample custodian.

3.0 SAMPLE PRESERVATION

Samples will be preserved at low temperatures and kept in darkness during transport to the laboratory for analysis. Appropriate chemical preservation will be performed in the field for various test parameters at the time of sampling. Sample containers will be provided by the analytical laboratory. Each lot of sample containers will be checked for cleanliness by the laboratory and sealed to prevent contamination.

Methods of sample preservation are generally intended to; 1) retard biological action, 2) retard hydrolysis of chemical compounds and complexes, 3) reduce volatility of constituents, and 4) reduce absorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and freezing. A summary of container types and preservation methods is provided in **Table SOP-7-1**.

4.0 SAMPLE IDENTIFICATION

A numbering system will be used to allow tracking of sample information and positive identification of sample results. Each sample number will consist of a variable code that indicates sample matrix, sampling point, sample date, and sample type.

Sample Matrix

A two letter designation will be used to identify the specific type of sample being taken. The identifiers will consist of the following:

- DB - Deep bedrock well
- SB - Shallow bedrock well
- SG - Shallow glacial well
- WB - Weathered bedrock well
- MW- Monitoring well groundwater sample; and
- RW - Residential well groundwater sample

Sample Point

The sample point will consist of a two digit number which will be used to identify the sample location. The sample location numbers have previously been assigned.

Sampling Date

The sample date will be identified by a six digit date code, i.e., 101497 (October 14, 1997).

Sample Type

A three character code will be used to identify the sample type (i.e., investigative or QA/QC). Quality assurance/quality control samples will be given a unique sample number which corresponds with other sample identification numbers of similar sample types. The identity of the QA/QC sample will be documented on the sample field sheet and in the log book. The sample type identifiers are as follows:

- 00D - Duplicate investigative sample
- 0FB - Field blank
- 0TB - Trip blank
- 0MS - Matrix spike sample
- MSD - Matrix spike duplicate sample

An example sample identification is shown below:

- MW16DB00D101497 would indicate a duplicate groundwater sample collected from monitoring well 16 on October 14, 1997. This is a duplicate sample and MW16 is a deep bedrock monitoring well

5.0 SAMPLE LABELING

Following sample collection, each container will be identified by field personnel with a self-adhesive label to indicate the project name, contractor job number, sample identification number, time, date, initials of the sampler, preservative(s) added, and analysis requested. An example label is shown in **Figure SOP-3-2**.

6.0 FIELD DOCUMENTATION

Field activities will be documented through completion of boring logs, field sample sheets, and entries into field log books dedicated to the project. An example boring log is shown in **Figure SOP-3-3**. Log books will contain information on a chronological or event-oriented basis. In general, log books will contain general site information such as:

- Site activities.
- Personnel present.
- Visitors.
- Weather conditions.
- Samples collected.
- Changes in procedures or sample locations and reason for change.

Entries will be made in waterproof ink. The pages will be sequentially numbered. The use of auxiliary data sheets, i.e., boring logs, will be referenced in the notebook. Errant entries in the log book will be stricken with a single slash mark, corrected (if necessary), and initialed.

Field documentation (field sheets, boring logs, etc. see Febure SOP- 3-4) will contain, at a minimum, the following information as is applicable to the specific task at hand:

- Project name and number.
- Date/time/weather.
- Personnel present.
- Sampling location.
- Sampling method.
- Sample number.
- Sample time.
- Sample depth, total depth of boring, as appropriate.
- Visual description.
- Type of sample.
- Photo number (if applicable).

- Air quality readings (if applicable).
- Instrument calibration.
- Sample container types, shipping; and analysis.
- Other general information, and observations.

Entries into the logbook will contain a variety of information. At the beginning of each entry, the date, start time, weather conditions, names of all sampling team members present, level of personal protection being used, and the signature of the person making the entry will be entered. Field sampling or investigation team personnel, the names of visitors, and the purpose of their visit to the site will be recorded in the field logbook.

All entries will be made in ink and no erasures will be made. If an incorrect entry is made, the information will be crossed out with a single strike mark and initialed by the person who made the strike. Whenever a sample is collected or a measurement is made a detailed description of the location of the station, which includes compass and distance measurements, shall be recorded. The number of the photographs taken at the station will also be noted. All equipment used to make measurements will be identified, along with the date of calibration.

[redacted]

Chain [redacted]
Custod[redacted]ecord

FIGURE SO[redacted]-1

Quante[redacted]
Environmental Services

QUA-4124

Client	Project Manager	Date	Chain Of Custody Number 14676
Address	Telephone Number (Area Code)/Fax Number	Lab Number	Page ______ of ______

City	State	Zip Code	Site Contact
Project Name			Carrier/Waybill Number
Contract/Purchase Order/Quote No.			

Sample I.D. No. and Description	Date	Time	Sample Type	Total Volume	Containers Type	Containers No.	Preservative	Condition on Receipt	Analysis											

Special Instructions

Possible Hazard Identification
☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal
☐ Return To Client ☐ Disposal By Lab ☐ Archive For ________ Months

Turn Around Time Required
☐ Normal ☐ Rush

QC Level
☐ I. ☐ II. ☐ III.

Project Specific (Specify)

	Date	Time		Date	Time
1. Relinquished By			1. Received By		
2. Relinquished By			2. Received By		
3. Relinquished By			3. Received By		

Comments

DISTRIBUTION: WHITE - Stays with Sample; CANARY - Returned to Client with Report; PINK - Field Copy

TABLE SOP 3-1
CONTAINER, PRESERVATION, AND HOLDING TIME REQUIREMENTS FOR WATER SAMPLES

PARAMETER	MATRIX	MINIMUM SAMPLE SIZE	CONTAINER	FIELD SAMPLE PREPARATION	SAMPLE PRESERVATIO N	HOLDING TIME
Filtered Metals	Water	500ml	1000ml Poly	Filtration	HNO_3 to pH<2,4C	6 Months*
Volatile Organics	Water	120ml	3-40ml VOA vial	None	4C 4 drops Conc. HCL pH<2,4C	14 Days
Total Chromatographic Organics	Water	1L	1L Glass Jar	None	4C	14 Days, 40 Days**
Conductivity	Water	50ml	500ml	Field Procedure	NA	Field Procedures
pH	Water	50ml	500ml Glass or Poly	Field Procedure	NA	Field Procedures
Temperature	Water	100ml	Glass or Poly	Field Procedure	NA	Field Procedures
Redox	Water	100ml	500ml Glass or Poly	Field Procedure	NA	Field Procedures

Notes:

* Filtered metals holding time from sample date to analysis.

** Semivolatiles holding times from sample date to extraction and from extraction to analysis

FIGURE SOP-3-2
EXAMPLE SAMPLE LABEL

WOODWARD-CLYDE CONSULTANTS

PROJECT: Albion-Sheridan Township Landfill

SAMPLE NO.: MW015SB10149700S

DATE: 14 October 1997 TIME: ________

ANALYSIS: 40 ml Vial
Volatile Organics
PRESERVATIVE: 50% HCL

SAMPLERS: ______________________

BORING LOG

BORING

PROJECT NAME ____________________
PROJECT LOCATION ____________________
LOGGED BY ____________ DRILLED BY ____________
SURFACE ELEVATION ____________ ELEVATION DATUM ____________
WATER ENTRY DEPTH ________ FEET ATD
WATER SURFACE DEPTH ________ FEET ________ AD
COMMENTS ____________________

SHEET ______ of ______
PROJECT NO. ____________
TASK NO. ____________
DATE ____________
RIG ____________
METHOD ____________

DEPTH (ft)	SAMPLE TYPE	SAMPLE REC	SAMPLE RES	SAMPLE PP/HS	DESCRIPTION and (USC)	SYMBOL	FIELD NOTES

Woodward-Clyde Consultants

Figure No. ____

FIGURE SOP-3-3

SAMPLE COLLECTION FIELD SHEET

SITE NAME ____________________ PROJECT NO. ____________________

SAMPLE NO. ____________________ WELL NO. ____________________

DATE/TIME COLLECTED ____________________ PERSONNEL ____________________

SAMPLE METHOD AND DEPTH ____________________ ____________________

SAMPLE MEDIA (Circle 1): Soil Sludge Groundwater Surface Water

SAMPLE SPLIT (Circle 1): Yes No SPLIT SAMPLE NUMBER ____________________

Sample Container	Preservative	Analysis Requested

WELL PURGING

Date ____________________

HNu/OVA Measurements ____________________

Background ____________________

Well Head ____________________

Breathing Zone ____________________

Time Started ____________________

Time Completed ____________________

Well Depth (TOC) ____________________

Depth to Water (TOC) ____________________

Water Column Length ____________________

2" Casing X 0.16 gal/ft

Volume of Water in Well ____________________

Casing Volumes to Purge ____________________

Minimum Water to Purge ____________________

Comments ____________________

FIELD MEASUREMENTS

Time	Amount Purged (gal)	pH	Temp. (°C)	Conductivity (umhos/cm)	Color	Odor	Turbidity

---

FIELD EQUIPMENT AND CALIBRATION

	Instrument Model	Calibration
Water Level Indicator		
Conductivity Meter		
pH Meter		Before ______ After ______

Comments ____________________

____

FIGURE SOP-3-4

SOP-04

CALIBRATION AND MAINTENANCE PROCEDURES

The calibration and maintenance of instruments used to take measurements is an important aspect of the project's sampling program. As an activity which affects data quality, instrument calibration and maintenance will be performed in accordance with the instrument manufacturers specifications and established procedures by trained personnel.

1.0 FIELD INSTRUMENTS AND EQUIPMENT CALIBRATION

The calibration and general maintenance of field instruments is the responsibility of field team leaders or designated personnel. A field log book will be maintained by these individuals to document calibration, maintenance, and status of all instruments. The calibration record will contain, at a minimum the following information:

- Date and time of calibration
- Type of equipment and identification number
- Reference standard used for calibration
- Name of person conducting the calibration
- Results of calibration performed

A list of the field equipment scheduled for use during the investigation and the frequency of calibration and field maintenance is presented in **Table SOP-4-1**. Field calibration will be performed following the manufacturers directions and using standard solutions. Operation manuals for each piece of equipment will be kept in the field by the Site Manager or the Site Safety Officer.

Equipment that fails calibration, becomes questionable or inoperable during use will be removed from service and segregated to prevent inadvertent use. The equipment will be properly tagged to indicate that it is out of calibration. Equipment that cannot be recalibrated will be replaced.

2.0 PREVENTATIVE MAINTENANCE

To ensure that data generated for the project are reliable, all field equipment and instruments will have a prescribed routine maintenance schedule in addition to a calibration schedule. All field instrumentation, sampling equipment, and accessories will be maintained in accordance with the manufacturers recommendations and specifications and established field practice.

All maintenance will be performed by qualified personnel and documented by the appointed equipment manager or his designee. Documentation of maintenance performed will be similar to that for calibration and will become part of the project file. Documentation will include both scheduled and unscheduled maintenance. Unscheduled maintenance, particularly that which could have an adverse effect on field project performance, will be reported to the Field Team Leader.

The Site Manager or designee will review calibration and maintenance records on a regular basis to ensure that required maintenance is being performed as required.

TABLE SOP 4-1
PREVENTIVE MAINTENANCE PROCEDURES FOR FIELD INSTRUMENTS

INSTRUMENT	ACTIVITY	FREQUENCY
Redox Meter	Check Calibration	Twice daily
	Clean electrode	Each use
pH Meter	Check Calibration	Twice daily
	Immerse Probe in DI water	Each use
	Replace Batteries	As needed
Dissolved Oxygen Meter	Check Calibration	Daily
	Clean Probe	Each use
	Replace Batteries	As needed
Specific Conductance Meter	Check Calibration	Twice daily
	Clean Probe	Each use
	Replace Batteries	As needed
Thermometer	Inspect Instrument for change	Daily
	Replace Batteries (if digital)	As needed

SOP-05

QUALITY ASSURANCE/QUALITY CONTROL SAMPLING

1.0 DUPLICATE SAMPLES

Duplicates of selected samples will be collected and analyzed to check for sampling and analytical reproducibility and field representativeness. Duplicates will be collected by alternately filling the set of sample containers incrementally with equal volumes until all are full. As an example of this, a set consisting of four containers (sample plus duplicate) would be prepared by placing an equal volume of water into each container. The sampling device (dipper, bailer, etc.) is then refilled and the procedure repeated until each container is full. For volatile organic analysis (VOA) of water samples, each VOA vial will be filled separately.

2.0 BLANK SAMPLES

Blank samples will be analyzed to check for procedural contamination (equipment blank) and/or ambient conditions at the site that may cause sample contamination (trip blank).

Field Blank

Field blanks will not be collected for groundwater samples obtained using a bladder pump.

Trip Blank

A trip blank for volatile organic analyses (VOA) will be included in each sample shipment containing water samples for volatile organics analyses. The trip blank will consist of one or more 40 ml VOA vials filled with Milli-Q water. They will be prepared in the laboratory, transported to the field, and shipped with the other samples to the laboratory without being opened in the field. The trip blank will be documented on the chain of custody form for samples sent to the laboratory. One of the trip blank vials will then be analyzed for volatile organics.

3.0 MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES

Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected and analyzed to evaluate the effect of the sample matrix on the accuracy of the analysis. MS/MSD samples will be analyzed for organics only. Triple the normal volume of sample is required for volatile and semi-volatile organics.

SOP-06

WATER LEVEL MEASUREMENTS

1.0 OBJECTIVE

This document defines the standard procedure for measuring water levels in wells. This procedure describes equipment and field procedures necessary to collect water level measurements. SOP-8 describes decontamination procedures which are applicable to this SOP.

2.0 EQUIPMENT

The equipment necessary to measure water levels includes:

- Well keys
- Solinst Model 101 water level meter or equivalent resistivity type meter
- Two 5-gal buckets (with lids) or equivalent for decontamination
- Decontamination brushes
- Alconox soap
- Deionized or distilled water
- Potable water
- Spray bottle
- Field data sheets
- Field notebook
- Appropriate health and safety equipment

3.0 PROCEDURE

This section gives the sequence of events to follow when measuring water levels. Appropriate health and safety equipment, as described in the Health and Safety Plan (HASP) should be worn during well opening, well measurement, and decontamination.

- The water level probe shall be decontaminated prior to use in each monitoring well.

- Observations concerning the well pad, surface or protective casing and other well conditions will be documented in the field notebook.

- The depth of the static water level and the total depth of the well will be measured using an electric water level meter. The measuring point for all the wells shall be the top of monitoring well casing. If a reference mark is not found, then all well readings will be referenced to the north rim of the monitoring well riser pipe for standardization.

- The static water level and the total depth of the well shall be measured, recorded on the water level data sheet, and then immediately rechecked.

- All columns of field data sheets shall be completed, including time of measurement. If measurements are taken over a several-day period, the date of each measurement should be clearly indicated on the form.

- Care shall be taken to verify the readings during each water level measurement period. Any significant changes in water level will be noted by comparing the most recent measurement with past measurements.

- After any measurement is taken, the water level probe shall be decontaminated.

3.1 DECONTAMINATION

The water level indicator must be decontaminated before use, between wells, and at the conclusion of measurements. The probe will be decontaminated according to the procedure for decontamination of sampling equipment described in SOP-8.

4.0 DOCUMENTATION

Field data sheets or field notebooks will include date, time, well number, total well depth, water level, static water elevation, and comments. The data sheets or notebook shall be neat and legible, and shall be signed and dated by the person completing the page.

SOP-07
GROUNDWATERSAMPLING

1.0 OBJECTIVE

This document defines the standard procedure for collecting groundwater and surface water samples. This procedure gives descriptions of equipment, field procedures, and QA/QC procedures necessary to collect groundwater and surface water samples. The sample locations and frequency of collection will be specified in the Remedial Action Work Plan Field Sampling Plan (FSP).

This SOP is intended to be used together with the FSP and several other SOPs. Health and safety procedures and equipment that will be required during the investigation will be detailed in the Site Health and Safety Plan (HASP).

2.0 EQUIPMENT

Equipment used during well purging:

- Well keys.
- Electronic water level probe.
- Assorted tools (knife, screwdriver, etc.).
- Bailer.
- Low-flow Bladder Pump (Well Wizard pump).
- Pump discharge hose (with Well Wizard).
- Thermometer.
- pH meter (with automatic temperature compensation).
- Conductivity meter.
- Plastic squeeze bottle filled with deionized water.
- Polyethylene or glass container (for field parameter measurements).
- Paper towels or Kimwipes.

- Calculator.
- Field notebook.
- Waterproof and permanent marker.
- 55-gallon drum or holding tank for storing purged water.
- Appropriate health and safety equipment.
- Well completion information sheet.
- Appropriate decontamination equipment.

Equipment used during well sampling:

- Electronic water level measurement probe.
- Low-flow bladder pump (Well Wizard pump).
- Bailer.
- Thermometer.
- pH meter (with automatic temperature compensation).
- Conductivity meter.
- Redox potential equipment.
- Plastic squeeze bottle filled with distilled or deionized water.
- Cooler with ice.
- Polyethylene or glass jar for measurement of field parameters.
- Sample jars and labels. Sample bottles with preservatives added will be obtained from the analytical laboratory. Several extra sample bottles will be obtained in case of breakage or other problems.
- Peristaltic pump, dedicated tubing and dedicated disposable 45 -micron sterile filters.
- Paper Towels.
- Field notebook.
- Water sample collection form.
- Waterproof and permanent marker.
- Well completion information sheet.
- Appropriate decontamination equipment.
- Appropriate health and safety equipment.

3.0 PROCEDURE

This section gives the step-by-step procedures for collecting groundwater samples in the field. Observations made during sample collection should be recorded in the field notebook and field data sheet.

3.1 EQUIPMENT DECONTAMINATION

Before any purging or sampling begins, all well probes, bailers, and other sampling devices shall be decontaminated. If dedicated equipment is used, it should be rinsed with distilled water. Mobile decontamination supplies will be provided so that equipment can be decontaminated in the field. Each piece of purging or sampling equipment shall be decontaminated before sampling operations and between each well. The decontamination solutions shall be replaced with clean solutions between each well.

3.2 INSTRUMENT CALIBRATION

Electronic equipment used during sampling includes a pH meter with temperature scale and automatic temperature compensation, a conductivity meter, and a water level measurement probe. Before going into the field, the sampler shall verify that these instruments are operating properly. The pH and conductivity meters require calibration prior to use every day and must be recalibrated if they have been turned off. Calibration times and readings will be recorded in a notebook to be kept by the field sampler.

3.3 WELL PURGING

The purpose of well purging is to remove stagnant water from the well and obtain representative water from the geologic formation being sampled while minimizing disturbance to the collected samples. A dedicated low-flow (< 0.5 liter/min) pump will be installed in accordance with the manufacturer's recommended procedures for purging/sampling during the O&M monitoring program.

Before a sample is taken, the well will be purged until either:

1) a minimum of three to five well casing volumes have been removed using a low-flow Well Wizard pump.
2) field parameters have stabilized.

Evacuated well water will be discharged back down the well it originated from following completion of all purging/sampling activities.

The following procedures will be performed at each well:

- The condition of the outer well casing, concrete well pad, protective posts (if present), and any unusual conditions of the area around the well will be noted in the field logbook.

- The well will be opened.

- The condition of the inner well cap and casing will be noted.

- The depth of static water level will be measured (to nearest 0.01 foot) and recorded from the measuring point on the well casing, the measuring point (e.g., notch on north side, top of well casing) identified, and time indicated.

- The total depth of well from the same measuring point on the casing will be measured and recorded.

- The volume of water in the well casing will be calculated in gallons based on feet of water and casing diameter.

- From the above calculation, the three to five casing volumes to be evacuated will be calculated.

- An initial sample will be obtained from the purge pump for field measurements of temperature, conductivity, and pH, and for observation of water quality. This sample will not be retained after these initial measurements are recorded.

- Water in casing will be evacuated with a pump. Temperature, conductivity, and pH measurements will be taken after evacuation of each well volume to determine whether the water chemistry has stabilized. Generally, pH values within ±0.1 pH unit, temperature within ±0.5°C, and conductivity within ±10 µmhos/cm between consecutive readings indicate adequate stability of the water chemistry. If the chemistry is not stable, purging will continue, measuring pH and conductivity after each one-half well volume.

- Following stabilization, the remaining field parameters will be measured.

3.4 SAMPLE COLLECTION

Samples for chemical analysis will be collected within two hours after purging is completed. If samples are not taken immediately after purging (but within the two-hour limit) an additional one to two well volumes will be purged prior to sampling. For slow recovering wells, the sample shall be collected immediately after a sufficient volume is available. The water quality samples shall be taken from within the well screen interval. The following sampling procedure is to be used at each well:

1. Decontaminated or dedicated sampling equipment will be assembled.

2. Sample collection:

When Well Wizard is used for water sample collection:

- Purge Saver will be connected to the hose from the low-flow bladder pump.
- Low-flow bladder pump will be turned on.
- Purge parameters including temperature, pH and conductivity will be measured periodically until these parameters have stabilized readings. Remaining field parameters will be measured.

3. The individual sample bottles should be filled in the order given below:

   a) Volatile organic compounds (VOCs), if any
   b) Semivolatile organic compounds (SVOCs), if any
   c) Metals

   VOC sample vials should be completely filled so the water forms a convex meniscus at the top, then capped so that no air space exists in the vial. Turn the vial over and tap it to check for bubbles in the vial which indicate air space. If air bubbles are observed in the sample vial, discard the sample vial and repeat the procedure until no air bubbles appear.

   Filtered samples for metals will be collected in designated vials that contain appropriate preservatives.

   For samples requiring filtered analysis for metals, water aliquot will be field filtered using a 45 micron sterile filter prior to preserving and placement in to the appropriate sample bottle. Disposable filter units will be used to minimize potential cross contamination.

   Fill bottles for metals and water quality almost full.

Bottles will have preservatives added in the laboratory prior to shipment to the site and so labeled.

4. Identification labels for sample bottles will be filled out for each well.

5. Time of sampling will be recorded.
6. The well cap will be replaced and locked.

7. Field documentation will be completed, including the chain-of-custody.

3.5 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES AND SAMPLES

Field QA/QC samples are designed to help identify potential sources of sample contamination and evaluate potential error introduced by sample collection and handling. All QA/QC samples are labeled with QA/QC identification numbers and sent to the laboratory with the other samples for analyses.

Field Blanks

Field blanks will not be collected for samples obtained using a dedicated bladder pump.

Duplicate Samples

Duplicate samples are samples collected side-by-side to check for the natural sample variance and the consistency of field techniques and laboratory analysis. For the groundwater sampling a duplicate sample will be collected at the same time as the initial sample. The initial sample bottle for a particular parameter or set of parameters will be filled first, then the duplicate sample bottle for the same parameter(s), and so on until all necessary sample bottles for both the initial sample and the duplicate sample have been filled. The duplicate groundwater sample will be handled in the same manner as the primary sample. The duplicate sample will be assigned a QA/QC identification number, stored in an iced cooler, and shipped to the laboratory on the day it is collected.

Matrix Spikes and Matrix Spike Duplicates

Matrix spikes are used to determine long-term precision and accuracy of the laboratory analytical method on various matrices. For this procedure duplicate samples are collected at the well and spiking is done by the lab. Samples are labelled as matrix spikes for the lab. The matrix spike and duplicate will be collected at the same well.

4.0 SAMPLE IDENTIFICATION AND HANDLING

Samples will be identified, handled, and recorded as described in SOP-03.

5.0 DOCUMENTATION

5.1 FIELD SAMPLING DATA SHEET

A field sampling data sheet for groundwater samples (**Figure SOP-3-4**) will be completed at each sampling location. The data sheet will be completely filled in. If items on the sheet do not apply to a specific location, the item will be labeled as not applicable (NA). The information on the data sheet includes the following:

- Well number.
- Date and time of sampling.
- Person performing sampling.
- Volume of water purged before sampling.
- Conductivity, temperature, and pH during evacuation (note number of well volumes).
- Redox potential.
- Number of samples taken.
- Sample identification number.

- Preservation of samples.
- Record of any QC samples from site.
- Any irregularities or problems which may have a bearing on sampling quality.

5.2 FIELD NOTES

Field notes shall be kept in a bound field book. The following information will be recorded using waterproof ink:

- Names of personnel.
- Weather conditions.
- Location and well number.
- Date and time of sampling.
- Condition of the well.
- Decontamination information.
- Initial static water level and total well depth.
- Calculations (e.g., calculation of purged volume).
- Analyses that will be performed by the laboratory.
- Equipment calibration information.

5.3 WELL VOLUME CALCULATIONS

The following equation shall be used to calculate the volume of water to be removed during well evacuation:

For 2-inch well:

Evacuation Volume = (Total Well Depth (ft) - Water Level Depth (ft))
x 0.1632 gal/ft = gallons/1 well casing volume

Multiply the volume of one well casing volume by three (3) to obtain the minimum volume of water to be evacuated.

6.0 CALIBRATION

6.1 pH METER

The pH meter must be calibrated each day before taking any readings of samples and must be recalibrated during the day if it has been turned off after the initial calibration. Calibration and operation of the pH meter will follow the manufacturer's specific instructions. In general, calibration is done by adjusting the meter with standard buffers that bracket the expected pH of the field water. The buffers to be used are pH 4.0, 7.0, and 10.0. Calibration will consist of the following general procedures:

1. Adjust the reading of the pH meter using the intercept knob with the electrode placed in the pH buffer by using the calibration knob. Rinse the electrodes with distilled water between buffer adjustments.

2. With the electrode placed in another pH buffer, adjust the reading of the meter with the slope knob. Adjust using the temperature knob if the meter has no slope knob.

3. Repeat steps 1 and 2 until the meter gives acceptable readings ($\pm$0.1 pH unit) for all the buffers used for calibration.

Note: Always use the same electrode for measurements that was used in the calibration. Recalibrate the meter if the electrode is replaced. Although the temperature setting on the pH meter often does not match the sample temperature after calibration, the pH readings will still be accurate in these cases provided that the response to the buffers is correct.

Record the time of analysis and temperature of the buffer in the field notebook whenever the pH meter is calibrated.

6.2 CONDUCTIVITY METER

The conductivity meter must be calibrated each day before taking field measurements. Record time, temperature, and instrument response in the meter notebook. Calibration is done by noting the response of the meter to several standard conductivity solutions which bracket the values expected to be measured in the field. A standards of 1000 µmhos/cm should be adequate for the samples expected. If the instrument has a calibration adjustment, set the response to match the standards. Otherwise, simply record in the field notebook the instrument response to each standard.

6.3 REDOX POTENTIAL METER

The redox potential meter must be checked for proper operation each day before taking field measurements. The redox potential meter is checked for sensitivity using buffer solution recommended by the manufacturer. Record time and instrument response in the meter field note book.

SOP-08

FIELD EQUIPMENT DECOMTAMINATION

1.0 OBJECTIVE

Decontamination of personnel and equipment will be performed to limit the transport of contaminants to personnel to off-site areas and between work areas. Personnel decontamination protocol will be presented in the Health and Safety Plan. All sampling equipment coming in contact with soils, sediment, groundwater and surface water will be decontaminated prior to sampling, between sampling locations, between boring intervals, and at the completion of work. The objective of the procedure is to minimize the potential for cross-contamination of samples and accumulation of erroneous data.

2.0 EQUIPMENT

Decontamination equipment and supplies consist of the following:

- Potable water
- Wash tubs
- Alconox (or equivalent)
- Scrub brushes
- Hot water or high pressure
- Plastic sheeting
- Saw horses or pallets
- 5 gal buckets
- Garbage bags
- Distilled water
- Hand spray bottle
- Methanol
- Sprayer

3.0 GENERAL

Decontamination of heavy equipment will occur in the main decontamination area. This area will be established for cleaning of augers, drill bits, drill rig, backhoe, large tools, and other large items.

Personnel and small sampling and field equipment decontamination may be performed outside the sampling locations or at the main decontamination area.

4.0 PROCEDURES

Small equipment will be cleaned using the following equipment procedures:

- Scrub with brush using Alconox soap (or equivalent) and potable water solution.
- Water rinse.
- Air dry.
- Place sampling equipment into new plastic bags (if necessary to store).

For removal of heavily-oiled residues, a methanol wash may optionally be included prior to the final distilled water rinse. This rinsate will be collected.

Large equipment will be decontaminated using procedures outlined below.

- Move equipment to designated area.
- Clean equipment using a high pressure or hot water wash. Scraping and scrubbing may be necessary to remove encrusted material. Items should be placed on saw horses or pallets to prevent contact with the ground.
- Place equipment on saw horses or pallets and allow to dry; protect against airborne dust or spray water cross-contamination.
- Decontaminated equipment (augers, drill rods, and associated equipment) will be stored on a clean decontaminated trailer.
- Sampling and field equipment should not come in contact with potential sources of contamination prior to moving to the next sample location.

5.0 HANDLING OF DECONTAMINATION FLUIDS

Equipment decontamination fluids will be transported to the north end of the landfill property where no waste has been identified and allowed to infiltrate.

APPENDIX C
FINAL REPORT

CONSTRUCTION QUALITY ASSURANCE PLAN ALBION-SHERIDAN TOWNSHIP LANDFILL CALHOUN COUNTY, MI

Prepared for
Cooper Industries
Houston, Texas

and

Corning, Inc.
Corning, New York

January 1997

Woodward-Clyde

38777 West Six Mile Road
Suite 200
Livonia, Michigan 48151
6E13045

TABLE OF CONTENTS

Section 1 Introduction 1-1

1.1 Organization Of Reports 1-1
1.2 Purpose Of Plan 1-1
1.3 Plan Users 1-1
1.4 Scope Of Cqap 1-2

Section 2 Responsibility And Authority 2-1

2.1 Definition Of Parties And Terms Of Reference 2-1
2.2 Project Team Organization, Responsibilities And Qualifications 2-2
2.2.1 The Group 2-2
2.2.2 Project Coordinator 2-3
2.2.3 U.S. EPA Project Manager 2-3
2.2.4 Engineer 2-3
2.2.5 Contractor 2-3
2.2.6 QC Personnel 2-3
2.2.7 QA Officer 2-5
2.2.8 Surveyor 2-6

Section 3 Project Meetings And Inspections 3-1

3.1 Preconstruction Meetings And Inspections 3-1
3.2 Progress Meetings 3-1
3.3 Problem/Deficiency Meetings 3-1
3.4 Pre-Final Inspection 3-1
3.5 Final Inspection 3-2

Section 4 Construction QA Requirements 4-1

4.1 Construction Qa Evaluation 4-1
4.2 Qa Officer Qualifications And Responsibilities 4-1
4.3 Qc Personnel Qualifications And Responsibilities 4-2
4.4 Contractors Qualifications And Responsibilities 4-3
4.5 Inspection And Testing Requirements 4-4

Section 5 Documentation 5-1

5.1 Daily Summaries 5-1
5.1.1 Observation And Testing Data Sheets 5-1
5.1.2 Problems, Deficiencies And Corrective Measures 5-2
5.2 Destructive Test Reports 5-2
5.3 Photographic Reporting Forms 5-3
5.4 Design And/Or Specification Changes 5-3
5.5 Progress Reports 5-3

TABLE OF CONTENTS

5.6 Record Drawings 5-3
5.7 Final And Summary Report 5-4
5.8 Storage Of Records 5-4

Attachment A Inspection And Test Reporting Forms

1.1 ORGANIZATION OF REPORTS

This Construction Quality Assurance Plan (CQAP) is part of the Remedial Design (RD) for the Albion-Sheridan Township Landfill (ASTL) Site in Calhoun County, Michigan. Woodward-Clyde Consultants (WCC) has prepared the RD on behalf of Cooper Industries and Corning, Inc. (The Group) according to the Remedial Design Work Plan (RDWP) dated April, 1996, the Record of Decision (ROD) and the subsequent Unilateral Administrative Order (UAO) Statement of Work (SOW) issued for the site.

The RD contains the design drawings and specifications and the associated Remedial Action Implementation Drawings to implement the remedial actions at the Site.

1.2 PURPOSE OF PLAN

This CQAP describes the responsibility and authority of all organizations and key personnel associated with construction quality evaluations of the Remedial Action (RA). In addition to the CQAP, the following documents are referenced:

- RA Work Plan
- Drawings and Specifications
- General Contract Conditions
- Health and Safety Requirements (as outlined in the specifications and included in the Contractor-provided Construction Health and Safety Plan)

The procedures outlined in this CQAP are necessary to provide a level of confidence that the completed facility will meet contractual and regulatory requirements, conforms to the design drawings and specifications, and meets or exceeds all design criteria. Observations and documentation of the quality control are the main emphasis of the CQAP. Implementation of the plan will provide evidence that the construction was performed according to the Contract Documents. Documentation associated with CQA activities will assist in identifying problems as they occur during construction, and provide evidence that the problems were addressed before construction is completed.

1.3 PLAN USERS

Everyone involved in the management of the construction is required to be familiar with this document. All involved parties should review this document with particular attention to those sections applicable to their responsibilities.

1.4 SCOPE OF CQAP

The procedures addressed in the CQAP are intended to facilitate proper construction and use of materials associated with building of the landfill cover, monitoring systems, and stormwater and erosion control structures.

The elements of this plan include: (1) defining the responsibility and authority of organizations and key personnel, (2) presenting the qualifications of the Quality Assurance (QA) Officer and Quality Control (QC) inspection and testing personnel, (3) summarizing the activities, meetings, and required submittals necessary to document landfill component construction activities, (4) introducing the sampling requirements addressed in the specifications, and (5) describing in detail the documentation to be completed, organized and archived at the contract closeout phase of work.

The Landfill cap construction activity consists of the following elements:

Drum Removal and Treatment

- Excavation and handling .
- Testing and disposal.
- Soil Testing.

Gas Collection System

- Materials.
- Installation.

Landfill Cover

- General grading and fill.
- Excavation and placement of waste.
- Gas collection/Foundation layer.
- Geotextiles and geosynthetics.
- Flexible Membrane Liner (FML).
- Drainage layer.
- Vegetative soil layer.
- Seeding and mulching.

Stormwater Management System

- Grading and material selection.
- Flow control system inlets and outlets.
- Storm water conveyance system.
- Erosion control system.

Monitoring System

- Groundwater wells.

Security System

- Chainlink fence and gates.

2.1 DEFINITION OF PARTIES AND TERMS OF REFERENCE

The Terms of Reference are presented to define the terms used in the CQAP. The identity, qualifications, responsibilities and authority, regarding individuals/parties are discussed in subsequent sections of the Plan.

Construction Quality Assurance: Planned and systematic procedures developed to ensure that materials and services meet the requirements of the specifications. Construction quality assurance complements construction quality control. In general, CQA refers to procedures employed by the Engineer and QA Officer to document that the completed work meets or exceeds design criteria and conforms to the project drawings and specifications.

Construction Quality Control: Construction quality control (CQC) provides a means to measure, regulate, and compare the characteristics of a material and/or service. CQC refers to those actions taken by QC Personnel/Manufacturer(s) to ensure that materials and workmanship meet the requirements of the project.

Contractor: The individual or firm, referred to as the "Contractor," responsible for constructing the landfill component systems in conformance with the project documents. The Contractor will meet the requirements of the General and Supplemental Conditions of the Contract.

Contract Documents: All documents which are incorporated into the contractor's contract will include, the ROD, the Unilateral Administrative Order and SOW, the RA Work Plan, the Project Manual, the Design Specifications, the Design Drawings, the Project Schedule, the modifications approved at the pre-construction and/or other meetings.

Engineer : The firm responsible for the design and resident engineering responsibilities on behalf of the owner. The Resident Engineer is an individual, designated by the owner as their representative responsible for remedial design and for onsite management of the construction of the RA.

The Design Engineer is the person responsible for the design and shall evaluate all design changes or non-conforming construction.

Material Testing Laboratories: Laboratories utilized to perform physical testing of material samples. The laboratories shall be accredited by the Geosynthetic Accreditation Institute - Laboratory Accreditation Program or equivalent for membrane testing. Testing equipment used in the laboratories shall be calibrated at reasonable intervals by devices of accuracy traceable to either the National Bureau of Standards or accepted values of natural physical constants. Laboratories will have personnel qualified and experienced in performing tests required and be able to furnish test results within 3 days of reception of samples.

Owner: Cooper Industries and Corning, Inc. (the Group) are responsible for implementing the ASTL Remedial Action.

Project Coordinator: The individual (or firm) designated by the Group who is responsible for the work required to complete the components of the U.S. EPA RA.

Quality Assurance Officer: The individual (or firm) designated by the Group to be responsible for observing, testing and documenting activities related to the CQA during the construction of the landfill cap.

Quality Control Personnel: The individual (or firm) designated by the Group to be responsible for performing and documenting Quality Control activities during construction of the landfill cap. The Firm providing the QC Personnel will provide to the Group, and the Engineer, the corporate history, inspection capabilities, and resumes of personnel to be assigned to the project for approval.

Surveyor: A registered Surveyor that is not employed by the Contractor. The Surveyor will perform Measurement and Payment surveys as required by the Engineer, and perform QA auditing and verification of the construction survey work performed by the Contractor's surveyor. The Surveyor shall provide certification that the work completed as part of the landfill cover was constructed to the lines and grades indicated on the record/as-built drawings. The Contractor shall be responsible for employing a registered surveyor to develop survey control plan drawings, set survey control, develop cross-sections and record drawings.

2.2 PROJECT TEAM ORGANIZATION, RESPONSIBILITIES AND QUALIFICATIONS

A project construction team will be assembled that includes representatives of the Group, U.S. EPA, Michigan Department of Environment Quality (MDEQ), Project Coordinator, Engineer, (and the Resident Engineer and Design Engineer), QC Personnel, QA Officer, Health and Safety Officer, Surveyor, and the Contractor(s). The project team members will be appointed based on their professional qualifications applicable to their responsibilities, training and experience working with similar RA. Reference to the RA Work Plan will provide additional information concerning the qualifications and responsibilities of the individuals forming the project team. The organizational chart for the project team is presented in Figure 2-1.

2.2.1 The Group

The Group is responsible for all phases of the RA design, including the project management and construction of the landfill cover for which this CQAP applies. The Group has the responsibility of ensuring that the facility is constructed, within a reasonable degree of certainty, to meet the design criteria as evidenced by complete documentation of CQA activities. The Group has the authority to select, and/or dismiss, parties charged with CQA and construction activities. The Group also has the authority to accept or reject CQA drawings, recommendations of the QA Officer, and the materials and workmanship of the Contractor(s) when such is not in conformance with the requirements of the terms and conditions of the Contract Documents. The Group will designate a Design Engineer who will be responsible for the design of the RA and a Project Coordinator who will be responsible for coordinating the RA activities. The Group will appoint a Resident Engineer responsible for the overall management for all phases of the construction.

2.2.2 Project Coordinator

The Project Coordinator will have the responsibility for implementing the remedial action design for the RA and will be responsible for coordinating all phases of the construction and communication with the construction team. As a part of these responsibilities, the Project Coordinator has the authority to accept or reject drawings and specifications for the RA, implementation drawings, reports, and the materials and workmanship of the RA Contractor(s).

2.2.3 U.S. EPA Project Manager

U.S. EPA is responsible for the Agency oversight and management of the ASTL RD/RA Program and will designate an individual as the U.S. EPA Remedial Action Project Manager. The U.S. EPA project manager will be responsible for the overview of this project and will coordinate the agency review and approval of the RA.

2.2.4 Engineer

The Engineer will have a Resident Engineer that is the Group's onsite representative. The Resident Engineer will be responsible for the onsite management and coordination of the RA construction. The Resident Engineer has the overall responsibility for the construction management at the site and all communications with the Contractor, QC Personnel, Surveyor, and the Project Coordinator.

The Resident Engineer will work closely with the Contractor, QC Personnel, QA Officer, and Surveyor to provide the overall onsite project control for construction and CQA activities. The Resident Engineer will review and approve (as appropriate) the technical drawings, procedures and policies necessary to complete the project in conformance with the drawings and specifications. The Resident Engineer will monitor activities to ensure that the work performed is in accordance with schedules and will also be responsible for the overall quality of services. The Resident Engineer will prepare and submit all project reports and deliverables to the Project Coordinator.

2.2.5 Contractor

The Contractor is responsible for constructing the landfill cover and associated systems in conformance with the project documents. Contractor is responsible for the quality of suppliers, manufacturers, products, services, site conditions and workmanship to produce work of specified quality.

2.2.6 QC Personnel

The Contractor is responsible for scheduling QC activities with the QC personnel during construction. This work will be performed by an individual (or firm) independent of the Contractor. The individual firm must be approved by the Group. The firm providing QC Personnel will provide to the Group, and the Resident Engineer, the following information for the proposed firm: corporate history, proof of insurance, inspection capabilities, and specific related experience and resumes of personnel to be assigned to the project.

To facilitate QA/QC activities during construction, the Contractor will furnish incidental labor as required to: (a) provide access to work to be tested, (b) obtain and handle samples at the site or at the source of the product to be tested where and when designated by the Resident Engineer or QA Officer, (c) facilitate inspections, tests and retests. The Contractor will maintain accessibility of the work to the QC personnel and the QA Officer.

The QC personnel will assist the QA Officer in preparing CQA reports. The CQC report will, at a minimum, include: (a) QC personnel field notes; including memorandum of meetings and/or discussions, and (b) QC personnel observation and testing data sheets. Observation and testing data sheets will, at a minimum, include the following information:

- Identify sheet number for cross referencing and document control.
- Date, project name, location, and other identification.
- Weather conditions.
- A reduced-scale Site Plan showing applicable work areas.
- Descriptions and specific locations of work being tested and/or observed.
- Test and sampling locations were taken.
- Summary of test results.
- Calibration or recalibration of test equipment.
- QC documentation for Materials received.
- Identification of the panels/seams completed and approved, and measures taken to protect unfinished areas.
- Identification of seams or panel areas requiring repairs.
- Identification of repairs completed.
- Decisions regarding acceptance of work and/or corrective actions taken in instances of substandard quality.
- QA Officer/Resident Engineer signature.

Items above should be organized on log sheets so that none are overlooked. Sample sheets are included in Attachment A.

The Contractor will employ a surveyor, registered in the State of Michigan, to set survey control benchmarks and earthwork stakes, develop cross-sections, and prepare record/as-built drawings.

The firm providing QC Personnel will provide for the services of independent material testing laboratories to support CQC requirements. Laboratories shall be approved by the Group and be accredited by the Geosynthetic Accreditation Institute - Laboratory Accreditation Program or equivalent for membrane testing.

Specific construction QC testing, documentation, and submittal requirements are presented in the Specification sections of the Contract Documents.

2.2.7 QA Officer

The QA Officer is responsible for completing audits of and providing documentation that materials and construction are in accordance with the project drawings and specifications. The QA Officer shall be an individual or established professional engineering firm incorporated or registered in the State of Michigan. The QA Officer is responsible for providing qualified personnel to observe and document landfill component construction and to certify that the construction, as observed, was performed in accordance with the specifications.

The QA Officer is responsible for reviewing Contractor's CQC data and performing CQA sampling and testing to confirm Contractors' CQC and manufacturer's quality control. The QA Officer will provide personnel with the appropriate academic training/experience in order to fulfill their specific responsibilities.

The QA Officer, or his/her designee, (e.g., the Resident Engineer) shall observe and document the quality control activities in sufficient detail and continuity to provide a level of confidence that the construction complies with the Contract Documents. The QA Officer may accept or reject construction not in conformance with the specifications. The QA Officer may inform the Resident Engineer to direct the Contractor(s) to test or retest to provide the required degree of certainty that the specified material(s) properties and the design requirements are achieved.

The QA Officer, his/her designee, shall maintain daily reports of construction and QA/QC activities. These daily CQA reports will, at a minimum, include: (a) field notes; including memorandum of meetings and/or discussions, (b) QA observation and testing data sheets, (c) QC observation and testing data sheets, and (d) construction problem and solution data sheets.

If a deficiency is discovered in the earthwork, the QA Officer shall immediately determine the extent and nature of the deficiency. If the deficiency is indicated by an unsatisfactory test result or unacceptable condition, the QA Officer shall evaluate the extent of the deficient area by additional tests, observation, a review of records, or other appropriate methods.

It is the responsibility of the QA Officer or his/her designee to report to the Resident Engineer and Contractor, any problem, deficiency, or deviation from the Contracts Documents. The QA Officer will schedule appropriate retesting through the Resident Engineer, performed at the Contractor's expense, after the deficiency is corrected.

All retests performed under the direction of the QA Officer must confirm that the deficiency has been corrected before any additional work is performed in the area of the deficiency. The QA Officer will audit records and constructions to confirm that applicable construction requirements are met and that all CQC submittals are provided.

Specific construction QC testing, documentation, and submittal requirements are presented in the Specification sections of the Contract Documents.

The qualifications of the CQA Officer shall be as follows:

- A minimum of 5 years related experience.
- The candidate shall have a minimum of 3 years field experience with projects involving construction of landfill liners or covers. This experience shall include at a minimum: interpretation of contract and specifications, resolving issues with

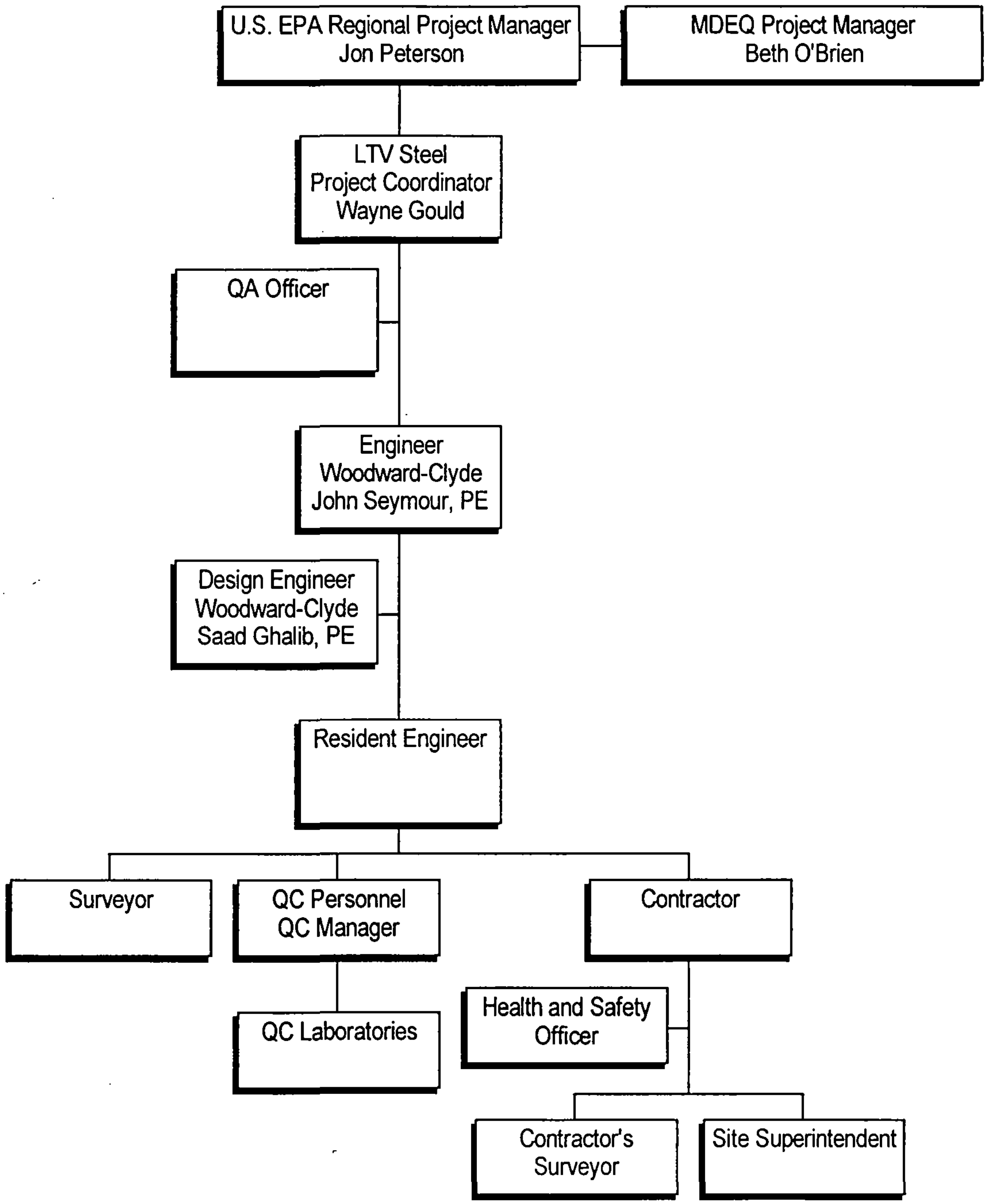
contractor and owner, general performance of construction personnel and equipment, field surveying techniques, and safe work practices.

- The candidate shall be knowledgeable of laboratory testing procedures (i.e., particle size, permeability, protors, etc.), and field testing (density, moisture content, etc.) of soil liner and cover materials.
- The candidate shall have at least 2 million square feet of geosynthetic inspection experience, including geomembranes, geosynthetic clay liners, geonets, and geotextiles and be versed in interpretation of geosynthetic laboratory test results for these synthetics.
- The candidate shall be familiar with construction invoices, schedules, issuing of work/change orders, shop drawings and other related items generally included as contractor submittals.

2.2.8 Surveyor

The Surveyor will be a professional engineer or land surveyor registered in the State of Michigan. The Surveyor, contracted to the Group and independent of the Contractor's surveyor, may elect to perform Measurement and Payment surveys as required by the Resident Engineer and perform QA auditing and verification of the construction survey work performed by the Contractor's Surveyor. The Surveyor shall provide certification that the work completed as part of the landfill cover was constructed to the lines and grades indicated on the record/as-built drawings. Surveying will be performed in conformance with the requirements of the Specifications. The Surveyor will work under the direction of the Resident Engineer and QA Officer.

FIGURE 2-1
PROJECT ORGANIZATION TEAM
ALBION-SHERIDAN TOWNSHIP LANDFILL
CONSTRUCTION QUALITY ASSURANCE PLAN



J:\6E13045\CQAP\FIG2-1.PPT

To ensure a high degree of quality during construction, clear channels of communication are essential.

3.1 PRECONSTRUCTION MEETINGS AND INSPECTIONS

The preconstruction meeting is discussed in Section _____ of the Construction Specifications.

3.2 PROGRESS MEETINGS

Regularly scheduled progress meetings will be held at the project field office of Contractor. The progress meetings will be held every Fourteen (14) days or less with the first meeting one week after the preconstruction meeting or one week or less after the date of Notice to Proceed. The Resident Engineer may call for additional meetings as necessary.

The Contractor will attend all progress meetings, and review previous meeting minutes prepared by the Resident Engineer, or his designee, and the current agenda items. The Contractor will be prepared to discuss pertinent topics such as deliveries of materials, equipment and progress of the work.

Submittals required at, or before, each progress meeting include (a) construction Schedule, (b) Monthly Status Report, and (c) Progress photos.

A detailed description of the progress meetings are provided in Section ____ of the specifications.

3.3 PROBLEM/DEFICIENCY MEETINGS

A problem/deficiency meeting or telephone conference call shall be conducted when a problem or deficiency is present or likely to occur. The purpose of the meeting is to define and resolve the problem or deficiency. The meeting will be held at the project field office of the Contractor. The QA Officer (or his/her designee) shall document and distribute minutes of problem/deficiency meetings. A detailed description of the problem deficiency meetings are provided in Section _____ of the specifications.

3.4 PRE-FINAL INSPECTION

Resident Engineer shall notify Project Coordinator, the Group, U.S. EPA, MDEQ, and Contractor for the purposes of conducting a Pre-final Inspection of landfill cover construction. Inspection will be held approximately 2 weeks after preliminary determination that construction is complete. The inspection shall consist of a walk-through inspection of the entire project.

A Pre-final Inspection Report will be prepared by the Resident Engineer and QA Officer for submission to U.S. EPA and MDEQ within fifteen (15) days after completion of the Pre-Final Inspection. This report will outline the outstanding construction items (incomplete/incorrect), actions to resolve items, completion date(s) for items, and date for Final Inspection. A detailed discussion of the Pre-Final inspection is provided in Section _____ of the specifications.

3.5 FINAL INSPECTION

Resident Engineer shall notify Project Coordinator, the Group, U.S. EPA, MDEQ, and Contractor for the purposes of conducting a Final Inspection when outstanding construction items have been completed and within fifteen (15) days of completion of work identified in the Pre-final Inspection Report. The final inspection shall consist of a site walk-through. The Pre-final Inspection Report will be used as a checklist for the final inspection.

The Resident Engineer and QA Officer shall prepare the Pre-final Inspection Report for submittal to U.S. EPA and MDEQ after thirty (30) days of completion of the Final Inspection. A registered professional engineer and the Project Coordinator will certify in this report that all items contained within the UAO and accompanying documents have been completed and that the remedy is functional and meets the design specifications.

4.1 CONSTRUCTION QA EVALUATION

Construction quality assurance evaluations shall be performed on all components of the construction. Criteria to be used for determination of acceptability of the construction work shall be as identified in the Contract Documents.

Construction evaluation testing will consist of: 1) Quality Control inspection, field and laboratory tests of the work, and 2) Quality Assurance auditing of quality control activities (to be performed by the QA Officer).

The Group representative will appoint, employ and pay for services of a Quality Assurance Officer (QA Officer) to perform QA inspection and testing as specified in the Contract Documents. Neither observations by the QA Officer, nor inspections, tests, or approvals by other than the Group's Representative shall relieve the Contractor from his obligation to perform the work in accordance with the requirements of the Contract Documents.

4.2 QA OFFICER QUALIFICATIONS AND RESPONSIBILITIES

The QA Officer will comply with all quality assurance requirements of the project specifications and this CQAP. General responsibilities of the QA Officer include the following:

- Perform confirmation inspections, tests, and other services specified in the individual specification sections as requested by the Engineer.
- Employ and pay for the services of an independent testing laboratory (or laboratories) to perform specified services and tests.
- Obtain approval of the Group's representative before employing laboratory (or laboratories).
- Secure and deliver to the laboratory adequate quantities of representative samples of materials, for requested testing.
- Utilize laboratories accredited by the Geosynthetic accreditation Institute's - Laboratory Accreditation Program or equivalent for membrane testing.
- Check to assure testing equipment has been calibrated at reasonable intervals by devices of accuracy traceable to either the National Bureau of Standards or accepted values of natural physical constants.
- Notify laboratory sufficiently in advance of operations to allow for laboratory assignment of personnel and scheduling of tests.
- Pay costs of testing laboratory services except for tests requested or required to be provided by the contractor.
- Estimate the extent and nature of deficiencies identified from observations or testing by performing additional tests, observations, a review of records, or other appropriate methods.

- Notify the Engineer and Contractor of deficiencies and schedule appropriate retesting after the deficiency is corrected.
- Confirm that all installation requirements are met and that all QC submittals are provided by the Contractor.
- Complete a daily report and logs on prescribed forms following procedures of the CQAP.

The qualifications of the QAO shall include:

- Has least 10 years engineering experience with at least 5 years experience with landfill design and construction.
- Accomplished the responsibilities QAO on at least one other CERCLA site.
- Has experience on at least five CERCLA projects as project manager, project director or QAO.
- Is a registered professional engineer in Michigan.

4.3 QC PERSONNEL QUALIFICATIONS AND RESPONSIBILITIES

The QC Personnel will perform all inspections and tests prescribed by the quality control requirements of the Contract Documents. The Contractor is responsible for compliance with all Quality Control requirements of the Contract Documents. General responsibilities of the QC Personnel include the following:

- Perform or be responsible for all quality control inspections and testing using a qualified individual or firm (accepted by the Group).
- Employ and pay for the services of an independent soil testing laboratory to perform geotechnical tests required by the project specifications.
- Provide geosynthetic testing services necessary to demonstrate the materials of the liner is in accordance with Quality Control specification during the installation of the liner. Testing shall be reviewed by the QA Officer for conformance with the technical requirements presented in the specifications.
- Select a qualified and experienced laboratory to perform tests as specified for FML. The laboratory and shall be able to furnish test results within 3 days of reception of samples. The following laboratories have been pre-qualified for performing the required FML testing:

GeoSyntec Consultants	J&L Testing Co., Inc.
621 NW 53rd St., Suite 650	938 S. Central Ave.
Boca Raton, FL 33487	Canonsburg, PA 15317
(800) 926-4436	(412) 746-4441

Advanced Terra Testing, Inc.	TRI-Environmental, Inc.
833 Parfet St.	9063 Bee Caves Road
Lakewood, CO 80215	Austin, TX 78733
(303) 232-8308	(800) 880-8378

- Utilize laboratories that are accredited by the Geosynthetic Accreditation Institute's - Laboratory Accreditation Program or equivalent for membrane testing.
- Calibrate testing equipment at reasonable intervals by devices of accuracy traceable to either the National Bureau of Standards or accepted values of natural physical constants.
- Cooperate with the QA Officer; furnish samples of materials, design mix, equipment, tools, storage and assistance as requested.
- Secure and deliver to the laboratory adequate quantities of representative samples of materials which require prequalification testing.

4.4 CONTRACTORS QUALIFICATIONS AND RESPONSIBILITIES

The Contractor shall provide for the following:

- Furnish incidental labor and facilities:

  To provide access to work to be tested.

  To obtain and handle samples at the project site or at the source of the product to be tested where and when designated by the QC Personnel, Engineer or QA Officer.

  To facilitate inspections and tests.

  For storage and curing of test samples as appropriate.

- Correct deficiencies identified by the QC Personnel, QA Officer or Resident Engineer to the satisfaction of the Resident Engineer.

  All retests performed must confirm that the deficiency has been corrected before Contractor may perform any additional work in the area of the deficiency.

  Assume costs associated with retesting required due to non-conformance with specified requirements. Payment for retesting will be charged to the Contractor by deducting inspection or testing charges from the Contract Sum/Price.

- Assume the costs associated with providing the QA Officer test results, statements and certificates indicating the quality of materials and equipment used in the performance of work under this Contract. All costs of this testing and providing statements and certificates of quality assurance shall be a subsidiary obligation of the Contractor, and no extra charge to the Group shall be allowed on account of such testing and certification.

- Notify QC Personnel sufficiently in advance of operations to allow for field and laboratory assignment of personnel and scheduling of tests.
- Obtain approval of the Group before employing any laboratory (or laboratories).
- Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce work of specified quality.
- Comply fully with manufacturers' instructions, including each step in sequence.
- Request clarification from Resident Engineer before proceeding with Manufacturers' instructions that conflict with Contract Documents.
- Comply with specified standards as a minimum quality for the work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- Contractor shall require material or product suppliers or manufacturers to provide qualified staff personnel to observe site conditions, conditions of surfaces, installation, and quality of workmanship, as applicable, and to initiate instructions when necessary.
- Contractor shall submit qualifications of Manufacturer's Representative to Engineer 30 days in advance of required observations. The Manufacturer's Observer is subject to approval of Resident Engineer.
- Contractor and Manufacturer's Representative shall report to the Resident Engineer observations and site decisions or instructions given to installers that are supplemental or contrary to manufacturers' written instructions.
- Contractor shall submit to the QA Officer a report detailing Manufacturer's Representative activities within 30 days of observation to Engineer for review.

The qualifications of the Contractor shall include:

- Has completed at least five landfill capping projects.
- Has completed the installation of at least two million square feet of HDPE geomembrane.
- Is a licensed contractor in Michigan.

4.5 INSPECTION AND TESTING REQUIREMENTS

Construction QC will be conducted by the QC personnel. No testing or inspection by others shall relieve the contractor from meeting the requirements of the contract documents. The contractor may employ independent QC personnel to assist the Contractor in meeting quality requirements.

Construction activities subject for inspection and testing include, but are not limited, furnishing, installing and maintaining site roads, cover system, stormwater drainage, slope protection and erosion control, gas collection and venting system, monitoring well installation, abandonment of wells, perimeter fence and landscape grading and seeding.

Specifications for work associated with the construction of the landfill cover and other systems required to complete the remedial action as specified by the ROD and the SOW are included in the project manual.

Applicable specification sections are listed below:

To be completed as part of the 95% Design

The QA Officer, or his designee, shall confirm that all CQA requirements have been addressed and provide the Resident Engineer with signed descriptive remarks, memorandums, data sheets, and checklists to confirm that all monitoring activities have been completed. The QA Officer will maintain a current CQAP, checklists, test procedures, daily logs, and other pertinent documents. The Resident Engineer shall be responsible for the on-site maintenance of a complete specifications manual indicating the construction QA/QC requirements of the work. QC Personnel shall maintain records of all QC testing and inspectors and make the records available for audit by the QA officer.

Several inspection and test reporting forms which may be used by QC Personnel or the QA Officer to facilitate CQA reporting are presented in Appendix A.

5.1 DAILY SUMMARIES

The QC Personnel shall complete a daily QA/QC report summarizing construction QA/QC activities for the day. This report will be completed by the following day after the work and submitted to the Resident Engineer. Any matter requiring action by the Resident Engineer shall be highlighted. The daily QA/QC report will, at a minimum, include: (a) field notes; including memorandum of meetings and/or discussions, (b) observation and testing data sheets, (c) QC observation and testing data sheets, and (d) construction problem and solution data sheets.

5.1.1 Observation and Testing Data Sheets

The Contractor will assist QC Personnel in preparing the daily QA/QC report by providing a daily report to the QC Personnel. The daily report will, at a minimum, include: (a) Quality Control personnel field notes; including memorandum of meetings and/or discussions, and (b) QC Observation and Testing data sheets. Observation and testing data sheets will include the following information:

- Identifying sheet number for cross referencing and document control
- Date, project name, location, and other identification
- Weather conditions
- A reduced-scale Site Plan showing all work areas
- Equipment and personnel in each work area, including subcontractor(s)
- Descriptions and specific locations of work being tested and/or observed
- Locations where tests and samples were taken
- Summary of test results
- Calibration or recalibration of test equipment
- Materials received, including QC documentation
- Identification of the panels/seams completed and approved, and measures taken to protect unfinished areas

- Identification of seams or panel areas requiring repairs
- Identification of repairs completed
- Decisions regarding acceptance of work and/or corrective actions taken in instances of substandard quality, and

QC Personnel signature

Items above should be organized on log sheets so that none are overlooked. Sample sheets are included in Appendix A.

5.1.2 Problems, Deficiencies and Corrective Measures

The QA Officer will document construction problems, deficiencies, and solutions discussed in Problem/Deficiency Meetings. These memorandum shall be cross-referenced with associated CQC observation and testing data sheets prepared by the QC Personnel, and must include the following information, as applicable:

- Identifying number for cross-referencing and document control
- Detailed description of the problem or deficiency
- The location and probable cause of the problem or deficiency
- How and when the problem or deficiency was found or located
- Documentation of the response(s)
- Final results of any response(s)
- Measures taken to prevent a similar situation from occurring in the future
- The signature of the QA Officer/QC Personnel and Engineer indicating concurrence

These memorandum and all supporting data sheets, along with test results and the QA Officer's approval of the work, must be compiled by the QA Officer. These documents shall be included in the Final Certification Report prepared by the Resident Engineer and QA Officer upon completion of construction.

5.2 DESTRUCTIVE TEST REPORTS

The destructive test reports from all sources shall be collated by the QA Officer, or his/her designee. This includes field tests, Product data sheets, Installer's laboratory tests, and Geosynthetics QC Laboratory tests. A log of test sample results will be maintained by the QC Personnel on an ongoing basis, and submitted with the progress reports.

5.3 PHOTOGRAPHIC REPORTING FORMS

Photographic reporting shall be cross-referenced with Observation and Test Data sheet(s) and/or construction problem and solution data sheet(s). These photographs will serve as a pictorial record of work progress, problems, and mitigating activities. The basic file will contain color prints; negatives will also be stored in a separate file in chronological order. These records shall be presented to the Resident Engineer upon completion of the project.

5.4 DESIGN AND/OR SPECIFICATION CHANGES

Design and/or specification changes may be required during construction. Design and/or specification changes shall be made only with written agreement of the Engineer and the Design Engineer, and shall take the form of an addendum to the contract documents.

5.5 PROGRESS REPORTS

The QA Officer or his designee shall prepare a progress report once every two weeks, or at time intervals established at the pre-construction meeting. As a minimum, this report shall include the following information:

- Identifying number for cross-referencing and document control.
- The date, project name, location, and other information.
- Summary of work activities during progress reporting period.
- Summary of construction problems, deficiencies.
- Summary of weather conditions.
- Brief description of activities anticipated for the next reporting period.
- Signature of the QA Officer.

5.6 RECORD DRAWINGS

Record/As-Built construction drawings will be prepared by the Contractor's surveyor under the direction of the Engineer and reviewed by the Surveyor. At a minimum, the drawings should include the following information:

- Top dimensions of designated layer(s) of soil with spot elevations.
- Location and details of the earthwork construction including depths, plan dimensions, elevations, soil components thickness', etc.

The drawings shall address each of the construction components and, if necessary, additional drawings shall be used to identify problems or unusual conditions of the geotextile layers. In addition, applicable cross-sections shall show layouts of components which differ from the specifications.

5.7 FINAL AND SUMMARY REPORT

A CQA Final Report shall be submitted upon completion of the work and will include all documents prepared or compiled by the QA Officer. This report shall summarize the construction QA/QC activities of the project and the documentation for all aspects of the CQA plan performed. The CQA Final Certification Report will become a part of the Remedial Action Implementation Report and shall include as a minimum the following information:

- Personnel involved with the project.
- Scope of work.
- Outline of project.
- QA/QC methods.
- Test results (destructive and non-destructive, including laboratory tests).
- Certification sealed and signed by a registered professional engineer.
- Record Drawings, sealed and signed by a registered professional engineer.

The summary report that is prepared by the QA Officer shall also verify that construction was completed in compliance with the project drawings, the specifications and the CQAP. The CQC Personnel will assist the QA Officer as necessary to compile QC Observation and Testing Data reports, Manufacturer's QC certification forms, and other related information.

5.8 STORAGE OF RECORDS

All original records, especially those containing signatures, will be stored by the Engineer in a safe repository on site. Other reports may be stored by any standard method which will allow for easy access.

ATTACHMENT A

Inspection and Test Reporting Forms